Copyright

by

Kendra Michele Locklear

2012

The Thesis Committee for Kendra Michele Locklear
Certifies that this is the approved version of the following thesis:

Guidelines and Considerations for Biophilic Interior Design in Healthcare Environments

APPROVED BY
SUPERVISING COMMITTEE:

Supervisor:

Carl Matthews

Miroslava M. Benes

Guidelines and Considerations for Biophilic Interior Design in Healthcare Environments

by

Kendra Michele Locklear, BS Design

Thesis

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Interior Design

The University of Texas at Austin

May 2012

Dedication

To be able to further explore an affinity for plants and nature that I have known all of my life has been a joyous one. For this reason, I am to dedicate this thesis to my parents who have nurtured my love for plants, the natural environment, and an unrestrained creativity. My father's botany background, coupled with my mother's and his ability to see beauty in details and landscapes that others may interpret as mundane have certainly shaped my approach and thinking. I thank you both for the freedom to explore, dig up, and transform our back yard; for the many camping, Phlox–hunting, and hiking trips around Kansas, Nebraska, Missouri, Wyoming, and Colorado – areas with boundless beauty that emphasize our small human scale in the larger landscape; and finally, thank you, dad, for encouraging the exploration of the topic of biophilia and how it relates to my interests and professional experience.

Acknowledgements

Although it is my name that appears on this thesis, there are countless people who have influenced this process. Faculty, coworkers, family, and friends have all supported and influenced this work. Without their time and efforts to help focus my ideas, provide comments, and facilitate the freedom to explore an interdisciplinary topic, the project would not have been able to be completed.

I would like to begin by acknowledging Dr. Nancy Kwallek who worked with me in the earlier phases of my thesis project and offered guidance as to how to format my research, structure my proposal, and assisted me in moving from a scattered, broad idea to a more focused synthesis as presented here.

I would also like to acknowledge the two members of my thesis supervising committee, Carl Matthews, MS (Interior Design), and Dr. Miroslava M. Benes (Landscape Architecture), who were two of my initial professors as I began my graduate program at the University of Texas Austin. You both had a profound influence on my education and creativity as I made the transition from practice back into academia. I am thankful for your guidance and involvement in this project as the capstone of my graduate education. I respect and admire you both and appreciate the unique interior and landscape backgrounds you were able to bring to my research.

My experience at RTKL Associates, Inc. in Dallas also helped informed my knowledge of healthcare architecture and interior design. I would like to thank the many

colleagues, clients, and consultants that I encountered during my five years there. I especially would like to thank my design mentors and project teammates Jim Johnson, AIA, Christy Murphy, AIA, and Dori Mommers, RID, IIDA, for your dedication to the field and for the challenges and opportunities you presented to me. I also thank you for your friendship and supporting me on my decision to attend graduate school.

Lastly, I would like to acknowledge my wonderful fiancé and best friend, Frank Ordia. Without your love, support, and understanding, I would not have been able to get through these last two years. For this, I am most grateful.

Abstract

Guidelines and Considerations for Biophilic Interior Design in Healthcare Environments

Kendra Michele Locklear, MID

The University of Texas at Austin, 2012

Supervisor: Carl Matthews

At the heart of this thesis research lies the theory of biophilia which describes the innate affinity that humans have for nature and suggests a scientific hypothesis for environmental behavioral responses within the creative fields of architecture and design. Natural environments afford healing and restorative benefits in the form of positive shifts in cognitive, physical, and social functioning. Stress relieving benefits of natural environments are also widely recognized for their ability to provide a sense of control or privacy, a means for social support and interaction, opportunities for physical exercise and movement, and positive distractions through connection to nature. By creating verdant environments that are sensory-rich and accommodate physical experiences with nature beyond the passive experience of simply viewing it from the interior, a garden can provide healing benefits that extend past the architectural walls of the healthcare building. Through the introduction of guidelines and considerations, the field of healing landscape architecture has been able to design for positive environmental responses to create successful exterior healing environments. However, the same supportive characteristics, preferences, and stress relieving benefits of a natural healing environment need to be considered for the *interior* healthcare environment.

To further facilitate well-being, the built spaces need to be environments that reconnect the body and mind and foster a sense of place. These healing effects can be achieved through biophilic and sensory encounters within the facility. By focusing more on the human-environmental response research from environmental psychology, the methods for healing landscape architecture, and expanding on the principle of connection to nature in evidence-based healthcare design, healing interior environments can begin to be redefined. Using concepts of biophilic design to guide decisions for the built environment, spaces are designed to support healing through biophilic responses and connection to natural elements and systems. This thesis is meant to be viewed as a contribution towards developing evidence-based biophilic *interior* design solutions for healthcare environments. The interdisciplinary research and proposed guidelines are hypotheses for how to further design with nature for human well-being. They offer support and design considerations for psychological responses to nature within the *interior* healthcare environment.

Table of Contents

Glossary

Biophilia – The innate human predisposition to affiliate with natural systems and processes, especially life and life-like features of the nonhuman or natural environment (Wilson, 1984, 1; Kellert, Heerwagen, and Mador, 2008, 3).

Biophilic Design – The effort to translate an understanding of the innate human predisposition to affiliate with natural systems and processes – known as *Biophilia* – into the design of the built environment (Kellert, et. al., 2008, 3).

Body of Knowledge (BOK) - "…is a term used to represent the complete set of concepts, terms and activities that make up a professional domain, as defined by the relevant professional association. While the term body of knowledge is also used to describe the document that defines that knowledge—the body of knowledge itself is more than simply a collection of terms; a professional reading list; a library; a website or a collection of websites; a description of professional functions; or even a collection of information. It is the accepted ontology for a specific domain." (Wikipedia, 2012).

Consilience – "Literally a 'jumping together' of knowledge by the linking of facts and fact-based theory across disciplines to create a common groundwork of explanation"(Wilson, 1999, 7). For the purpose of this study, we will use E.O. Wilson's broader description of the theory that extends to the link between the sciences, humanities, and arts.

Evidence-based design (EBD) –The Center for Health Design defines EBD as "the deliberate attempt to base building decisions on the best available research evidence with the goal of improving outcomes and of continuing to monitor the success or failure for subsequent decision-making" (Malkin, 2008, 2).

Healing - The process that promotes overall well-being by providing relief of physical symptoms, facilitating stress reduction, increasing comfort, and supporting improvement in the overall sense of well-being (Marcus and Barnes, 1999, 3).

Restoration – A positive shift of cognitive, physical, and social functioning which is influenced by the affordance of the setting (Said and Baker, 2007-2008, 19).

Stress – A psychological or physiological response to a stimulus that offers exposure on a frequent basis to physical, social, or biological situations which influence or inform negative reactions that can accumulate causing physical ailment (Kopac, 2006, 101-102).

Therapeutic – Healing processes related to a specific aspect of a disease or needs of a given group of people producing measurable health outcomes (Larson, 2004, 3).

List of Figures

Chapter 1: Introduction

AIMS AND OBJECTIVES

The goal of this study is to synthesize the established research concerning human-nature relationships from the fields of Evidence-based Healthcare Design, Healing garden design (including therapeutic horticulture), and Environmental Psychology to generate systematic and replicable biophilic interior design guidelines and considerations that could positively influence the human condition, increase one's connection to nature, and enhance places of wellbeing within healthcare environments.

BACKGROUND INFORMATION

I have long had an interest in the connection of the interior and the exterior, and of people and plants. Having been raised by a father who is a botanist and a mother who shares his love for the natural, the horticulture knowledge I possessed and the amount of time I spent outdoors exploring nature as a child was far greater than that of my peers. It first appeared to me that this desire to be connected to nature and my love for all things green were primarily a result of my up-bringing and cultivated interests. However, as I entered college and chose to pursue another love of mine, the built environment, the study of Interior Design served as the framework which led to a career that has focused on large-scale healthcare design. During these past five years, the prevalence of Evidence Based Healthcare Design was becoming more main-stream. This approach attempts to base design decisions on the best available research with the objectives of improving outcomes and of continuing to monitor the success or failure for successive decision-making (Malkin, 2008, 2). However, the time necessary to explore the contributing components in detail was always lacking in the quick-paced world of commercial design in which I was involved. Nonetheless, one of the principles that instantly appealed to me and always seemed to be a reference point was "connection to nature." Typically revealed in the form of a landscape painting or photography, or views

onto courtyards, plazas, and rooftop gardens, this principle begs for more innovative applications and investigations that effectively and cohesively merge landscape and interior. The exploration for a more cohesive connection reveals that there is a deeper and broader psychological connection between humans and the natural than what I had previously viewed as a little girl's nostalgic association.

INTRODUCTION TO RESEARCH TOPIC

The recent and current building boom in the healthcare industry will shape such facilities for generations to come (Ulrich and Zimring 2004, Zimring and Bosch 2008). While government and industry best-practice initiatives are requiring these environments to follow the most current and innovative sustainable practices, many owners, administrators, and clinicians are taking a cue from Evidence-based Medicine and requiring qualified, valid, and credible research-supported design solutions as identified in Evidence-based Healthcare Design (Hamilton 2003). This methodology shifts design outcomes from being mostly subjective to a process incorporating objective, measurable outcomes; the field is altered from that of an art to that of a science by incorporating the relationship of architectural and behavioral outcomes within the context of healthcare facilities. Research has been conducted, and design professionals are increasingly becoming exposed to and accepting of the various attributing ideologies presented within this process. The process is viewed not as a dismissal of creativity, but as a catalyst to enrich and improve design solutions (Martin 2009). While Evidence-based Design does not offer a prescriptive solution, it does provide a springboard for innovative solutions that are driven by patient satisfaction, technological advancements, and the need to replace aging facilities (Cama 2009, Lavin 2011). Additionally, information regarding the concept of patient or family-centered care, evaluating staff workflow, determining how medical information is processed, and sustainability issues all help strengthen the principles of Evidence-based Healthcare Design (McCullough 2010). At the core of the Evidence-based Design process, is the principle of "connection to nature" which explores

how the built environment and the patient's orientation within the space can reduce stress, mitigate pain, and restore wellbeing (Smith 2007, Ulrich 1984).

Similarly, the fields of Landscape Architecture and Horticulture have compiled an historically-rich and extensive amount of research on the benefits of healing gardens and therapeutic horticulture, both of which are increasingly being incorporated into site plans at out-patient or extended care facilities (Marcus 1995, 1999). The American Horticulture Therapy Association (AHTA) maintains regional chapters that strive to disseminate information to the profession and healthcare providers in the form of publications and conferences and through the creation and management of a credentialing system (Relf 1992). Institutions such as the world-renowned Chicago Botanic Garden now offer a certificate program in Healthcare Garden Design, and professionals are continuing to emerge with specializations in this arena and are working with interdisciplinary teams to create garden environments of care in larger scale healthcare settings (Burnett 2003, Shoemaker and Diehl 2002, Simson 1998). Typically, horticulture therapy is offered as a supplemental treatment that utilizes passive or active exposure to nature and plant material to meet rehabilitation or therapeutic goals for participants with the ultimate goal of more holistically enhancing health and wellbeing (Haller and Kramer 2006, Ulrich 2002). The trend towards hospital environments that incorporate elements of nature or outdoor spaces is seen in the regional response to landscapes that are ecologically based allowing for cognitive, physical, and social connections for patients, staff, and family (Larson 2004, Marcus 2007, Naderi 2008, Said and Bakar 2007-2008, Tyson 1998).

Lastly, when looking at any body of research that deals with human reactions to space and the built environment, it is important to look at components of environmental psychology which are interwoven into the research contributing to Evidence-Based Design and Horticulture Therapy. Foundational theories of Human-Environment Relationships (i.e., Social Learning Theories, Integration Theories, Control Theories,

Behavior-Setting Theories, and Stimulation Theories) and especially those of Environmental Perception (i.e., Brunswick's Probabilistic Lens Model, Gibson's Affordances, Berlyne's Collective Properties, Pleasure-Arousal-Dominance Hypothesis, Kaplan and Kaplan's Framework, and Lynch's Elements of Legibility) all provide useful framework for evaluating a person's relationship to their environment and their reactions to nature or natural settings (Kopec 2006, Ulrich 1992). Recognizing the fact that a direct relationship between indoor environment and stress may be difficult to identify, the growing body of literature addressing the topic strives to focus more on the evidence that connects the two and looks specifically at environmental qualities and comfort. Research also describes how natural and architectural places can alter (positively or negatively) our perception of the environment and directly influence our ability to heal (Kline 2009, Mayer et al. 2009, Park 2006, Smith 2007). Finally, the theory of Biophilia, which is simply defined as people's innate affinity and desire for nature and natural systems, needs to be explored more in the context of interior design and how it incorporates environmental psychology and people-plant relations (Lewis 1996, Nisbet et. al. 2009, Sternberg 2009, Verges and Duffy 2009).

RESEARCH METHODS

This study will rely heavily on a review of previous literature from the fields identified above. Within this literature review, attention will be given to quantitative and qualitative evidence that supports tested hypotheses related to connection to nature and the subject's well-being. Examples of successful projects implementing Evidence-based healthcare design approaches will also be utilized to understand previous and current design solutions that increase connection to nature with preferential consideration given to projects that incorporate landscape concepts in the interior environment. These bodies of knowledge will then be analyzed for parallels and synergies that can inform new guidelines and considerations for Biophilic interior design of healthcare environments.

LIMITATIONS

The limitations for the study are primarily the result of the difficulty in conducting interdisciplinary research across a topic that has differing interpretations and degrees of relevance in the various fields of study. Until more recently, medicine has not been dedicated to studying the physical environment's effect on patient's well-being (Vincent, 2009, 61). Ethical and privacy measures make research of patient populations challenging considering that they are suffering physically or psychologically. Additionally, by tradition architecture is not a researched based field and most project timelines do not budget time or finances for empirical research, and the few that do often struggle with how that research should inform the design.

Chapter 2: Theory of Biophilia

SUMMARY

Biologist and Pulitzer Prize winner Edward O. Wilson is credited with the introduction of the term *biophilia* which he defined as the "innate tendency to focus on life and lifelike processes" (Wilson, 1984, 1). The hypothesis is further detailed in his personal memoir under the same title. E.O. Wilson described the inherent connection that humans have to nature as one interwoven into our genetic makeup and even more poetically as an emotional longing for the natural setting that is "the refuge of the spirit, remote, static, richer even than human imagination" (Wilson, 1984, 11). This dependence and desire for nature has deep-rooted history in the origins and survival of mankind and our learned associations, preferences, and emotions are related to these natural systems. We continue to learn about this connection as our society changes and our urban constructed world affects the environment, and, in turn, human health, productivity, and well-being (Kellert, Heerwagen, and Mador, 2008).

WHY IT IS IMPORTANT AS A FRAMEWORK FOR THIS STUDY

As a biological theory, biophilia offers an evidence-based methodology for design – in other words, it suggests a scientific hypothesis for behaviors within an artistic field. Wilson claims that both art and science are "enterprises of discovery" that depend on variations of analogy and metaphor (Wilson, 1984, 63-64). Both are explorations of the mind – a mind that is bound by our biology and our bond to nature – and one that explores new ideas by "argument, example, and experiment. Important science is not just any similarity glimpsed for the first time. It offers analogies that map the gateways to unexplored terrain…one commanding image synthesized from several units, such that a single complex idea is attained not by analysis but by the sudden perception of an objective relation" (Wilson, 1984, 67). The exploration of these complex relationships is becoming more evident in the growing body of knowledge in a number of diverse fields that support the hypothesis of connection to nature in direct relation to human health,

well-being, and productivity (Kellert, et. al., 2008). Much of the research looked at for this study provides empirical support for Wilson's theory of biophilia while many others explain psychological and healing effects of exposure and sensory involvement in the processes of the natural and built environment.

Chapter 3: Review of Existing Literature as Related to Biophilia and the Built Environment

CONSILIENCE

E. O. Wilson expanded on the association between the exploration of the mind in the fields of science and art in his more recent theory of *consilience,* which was popularized in another book he authored in 1999. Taking a concept that historically had been based in the natural sciences, he suggested a broader description that linked knowledge of cause-and-effect fact and theory across disciplines and boundaries of the sciences, humanities, and the arts. Each field and respective body of knowledge has its own experts, standards, language, and evidence, but when we concentrate on a particular topic within each of these bodies of knowledge, we can begin to understand how common theories can translate and inform a more detailed consideration of the issue at hand. The intention of the following review of existing literature as it relates to biophilia within the context of each field is meant to begin to create this link for further analysis.

ENVIRONMENTAL PSYCHOLOGY

Background

The field of science is based on the principles of discovery, investigation, and exploration in support of theories that evaluate and seek to prove a response to a specific stimulus. When considering behavioral responses, most social science fields, including various disciplines of psychology, seem to disregard or discount the level of influence the environment may have on forming our reactions. However, more recent studies have proposed theories explaining the drastic influence the environment does indeed have on human behavior impacting how we identify with the world around us, how we perceive ourselves within society, and how it affects our social behaviors (Kopec, 2006, 7). The human-environment relationship tends to be spoken of conceptually, and since the relationship cannot be considered in absolute terms, environmental psychologists tend to

offer theories to describe the probability of a specific behavioral reaction to an environment recognizing that it may not occur with all people and at all times (Kopec, 2006, 19). In the science of environmental psychology, the goal of these theories is not to provide answers but to guide research. This research contributes to the field's body of knowledge and eventually informs practice, or for the purposes of this study, design guidelines.

Environmental Psychology Theories

Our surroundings consist of stimuli such as noise, light, and temperature, the built environment made up of dimensions, furniture, and spaces, and representational objects that express meaning or ideas of a location all of which influence our reaction and interaction with an environment. These human-environment interactions can be characterized by the core psychological processes of arousal, overload, affect, adaptation, and personal control which all contribute to outcomes that can be classified as performance, health or stress, satisfaction, and interpersonal relationships (Kopec, 2006, 13).

Theories of Human-Environment Relationships

Social Learning Theories: Social and observational learning theories state that our method of learning is based on observation of others and then replicating the actions or behaviors that were first observed. Because of the order of sequence, these theories tend to differ from human-environment theories. There are three principles emphasized in social learning theories:

1. People are naturally inclined to see rewards and tend to avoid negative reinforcement.
2. Personality influences an individual's interaction with the environment and can become a framework for understanding specific responses.

3. Behavior is a key factor in interpreting observations and modeling actions. Cultural influences and the individual's experiences contribute to our subjective analysis and the resulting behavior (Rotter, Chance, and Phares, 1972; Rotter, 1982).

Integration (Integral) Theories: Integral theories consist of a broader category of concepts that describe the intricacy of the human-environment relationship. Isidor Chein proposes five major integral elements that work together to enable a certain behavior within a given environment:

1. Global environment (basic or general features of an environment)
2. Instigators (stimuli that prompt specific actions)
3. Goal objects and noxients (conditions or situations that are fulfilling or undesirable)
4. Supports and constraints (environmental aspects that encourage or discourage action)
5. Directors (features that instruct and move us towards a behavior) (Chein, 1954; Kopec, 2006, 20).

In addition to Chein's theory, there are three other elements that are regarded as part of the integral theory group: interactional, transactional, and organismic theories. The interactional theory discusses just that – the interaction of the human and the environment. Although separate, these two entities constantly interface with each other and determine or cause a reaction. The transactional theory relies on the concept of a mutually supportive relationship between the human and environment, citing nature as a simple example, based on the patterns of the interaction. Lastly, the organismic theory discusses how the complex relationship of culture, social learning, and personality can influence the way we react to an environment and may illicit a particular action or

behavior that may vary depending on the stimuli affecting the individual at that time (Gilford, 2002; Wapner, 1981).

Control Theories: A sense of control in an environment is a vital component of our well-being and can directly influence how we react to a use a space. There are three types of control that are discussed by James Averill related to human-environment:

1. Behavioral control: the capability to alter the environmental occurrence
2. Cognitive control: the capability to adjust our conception of the environment
3. Decisional control: the capability to select a reaction or response (Kopec, 2006; Weisz, Rothbaum, and Blackburn, 1984).

Variations of control exist in the form of primary control relating to more obvious levels of control of the environment, and secondary control being more accepting of the reality of an environment or occurrence. Personal control is also significant in human-environmental relationships and relates to the level of stimuli and our perceived or actual level of influence, freedom, and control in the setting. All of these factors then impact our feelings about the environment. By nature, most people are able to adapt to differing levels of environmental stimulation regardless of their actual level of control in the situation (e.g., at work versus at home). This adaptation or level of comfort may be most apparent in the level of territoriality or personal space claimed. As most peoples' adaptation level varies, so does their threshold for environmental stimuli and when that threshold has been reached or there is a perceived or real lack of control we typically try to alter or reassert control over the environment or situation. If repeated attempts fail to regain control, a person may suffer physical or psychological withdrawal and give in to learned helplessness deciding the situation beyond their influence or control (Altman, 1976; Brehm, 1966; Seligman, 1992).

Behavioral-Setting Theories: The behavior-setting theory is a concept that proposes that desired behaviors are encouraged by the setting or occasion in which they occur. Roger Barker, who conceived the model, recognized that by reinforcing desired behavior patterns early in life we can be taught to behave in a certain manner that is appropriate for the setting – known as operant conditioning. An essential principle within this theory is that of synomorphy stating that social and physical components of the environment should support each other. Differences will certainly arise as the interaction between the social and physical evolves and behaviors may also change due to motivation, culture, and time.

Since behavior settings deal with a desired behavior, it seems logical that they primarily relate to the public environment made up of three components:

1. Physical properties
2. Social influences
3. The environmental setting (Barker, 1968; Kopec, 2006, 22-23).

Stimulation Theories: The senses – sight, sound, touch, taste, and smell – all provide information about sources of stimulation within the environment, and stimulation theories seek to conceptualize and explain these relationships. Each element contributes to different sensory levels of stimulation. Several related theories such as the arousal perspective, environmental load or overstimulation, and adaptation, further explain stimulation and the human-environment behavioral responses. The effect of stimulation in the environment in the arousal perspective can be physically detected by an automatic physiological response such as increased blood pressure, heart rate, respiration, and adrenaline secretion (Berlyne, 1960; Wohlwill, 1966). Environmental load or overstimulation can occur when a person has reached the limit in their ability to process incoming information or stimuli leading to overload. In evaluating overload or arousal, it is important to find an acceptable and appropriate balance for the environment knowing

that the level of arousal may be vary among occupants and differing levels of adaptation will occur after repeated exposure to the stimuli in the environment.

Rachel and Stephen Kaplan, important contributors to human-environment relationships, also developed the attention restoration theory which fits in the larger context of stimulation theories. The concept behind their theory is that situations engage our attention, whether voluntary or involuntary at different levels and for different durations. Once overloaded, our attention begins to decline and lead to an inability to concentrate. In an effort to promote recovery and combat attentional fatigue, we need to experience effortless attention, such as a walk on the beach or in the woods that moves our attention function into an involuntary mode allowing the environment to restore our attention capacity (Kaplan and Kaplan, 1982; Kline, 2009, 161).

Theories of Environmental Perception

Brunswick's Probabilistic Lens Model: Egon Brunswick's theory maintains that the environment exhibits many cues which must be perceived by the inhabitant if they are to fully understand the beauty or purpose of the environment. He speaks of the framework of his model like a lens that helps the viewer analyze an individual interpretation of environmental stimuli, but continues to state that there is a certain probability that these stimuli will be useful in interpreting the human-environment relation. To further support his theory, he uses a group of preset independent cues that influence arrival at actual beauty and a group of personal judgments or impressions that indicate perceived beauty – both of which can result in an acute perception of the relationship between the environment and cues known as ecological validity. Finally, because of the personal aspect of this theory, complications may arise when we encounter cues or stimuli that are unfamiliar to us causing us to inaccurately analyze or misinterpret the environment (Brunswik, 1942; Brunswik, 1956; Kopec, 2006, 27-28).

Gibson's Affordance: James Gibson conceived the affordance theory as an ecological attitude towards environmental perception suggesting that instead of observing individual elements, the arrangement of substances, textures, and surfaces can provide cues for environmental features or function. Under this perception theory, he also stated that humans perceive and encounter their environments understanding the functional properties of such in different ways, which Gibson terms as affordances. In contrast to Brunswick's theory, the affordance theory maintains that it is the ecological organization of the environment that is more useful to our perception and relationship than individual cues or stimuli (Gibson, 1976; Gibson, 1979).

Berlyne's Collective Properties: One of the first models of aesthetics was created by psychologist Berlyne who developed his collective properties theory to explain our reaction to collective stimuli to form an aesthetic evaluation. It is the comparison of properties such as novelty, incongruity, complexity, and surprise that either conflict with or support our previous environmental experiences or perceptions that then help form our aesthetic evaluation of the current environment. Berlyne further defines the key concepts of his collective properties theory:

1. Novelty: an idea or object that is new, innovative, or used in a unique way (perceived positively)
2. Incongruity: a design element that is non-contextual (perceived negatively)
3. Complexity: an assortment of items in an environment
4. Surprise: exposes the unexpected (Berlyne, 1971; Berlyne, 1974)

In addition to the properties of the theory and independent of the perceiver's attitude, there are also two psychological dimensions that the viewer uses to form their aesthetic judgment:

1. Hedonic Tone: design features that do not possess a useful function other than providing pleasure or beauty.
2. Uncertainty-arousal: the feeling of uncertainty experienced by environments that are both complex and simple sparking feelings of concurrent excitement and discomfort (Berlyne, 1971; Berlyne, 1974)

Pleasure-Arousal-Dominance Hypothesis: Our response to the environment can be summed up in three ways according to Albert Mehrabian and James A. Russell. These emotional responses fall into the category of pleasure, arousal, and dominance which are based on the view that emotion is a mediator between our former stimuli, behavior, and the environment. Russel later proposed a revised model that eliminated dominance as an environmental response proposing a circumplex that shows pleasure and arousal at polar ends of axis offset by the negative version of each emotion. The notion of dominance as an emotional response is still wholly valid as the concept of control relates to environmental perception and resulting behavior. Elements that can affect pleasure, arousal, and dominance in an environment are typically the environmental stimuli such as light, temperature, etc. which can influence each person's perception of the space differently leading to a variety of emotional responses that can affect behavior or performance and relationships (Kopec, 2006, 30; Mehrabian and Russell, 1974; Russell, Ward, and Pratt, 1981).

Kaplan and Kaplan Preference Framework: Stephen and Rachel Kaplan proposed their preference framework as an explanation for the theory that people prefer environments that are "engaging and involved rather than simple or boring"(Kaplan and Kaplan, 1982; Kopec, 2006, 31). These environmental preferences are organized according to four elements:

1. Coherence: the convergence of cues in an environment that create a comprehensible setting.

2. Legibility: the level that an individual is able to comprehend or classify the setting and the cues within it.
3. Complexity: the amount or variety of elements within a setting (highly variable depending on the individual)
4. Mystery: the amount of hidden information or the need for exploration within a setting (Kaplan and Kaplan, 1982)

Lynch's Elements of Legibility: Kevin Lynch's concept of legibility was developed in the late 1950s when he was working as a city planner in Boston and can be applied to the built environment at any scale. He defined five elements that help increase understanding and classification of a space:

1. Paths
2. Edges
3. Districts
4. Nodes
5. Landmarks (Lynch, 1960)

Stress and Behavior

The previous section discussed theories and models for human perceptions and consequential behaviors as a result of environmental cues and stimuli. From these perspectives, it is obvious that the human-environmental relationship is tied closely to psychological functions. The term Psychoneuroimmunology was developed in the late 1980s as the science behind the interactions of psychological processes, the neuroendocrine system (nervous and hormonal systems), and the immune system (Vincent, 2009, 40). The immune system, disease, and stress are considered to be interrelated, and evidence suggests that stress is connected to decrease effectiveness of the immune system. When considering stressors in environments, we tend to think of the physical risks that can cause injury or lead to health problems, but we also must consider

the environmental factors that can negatively affect our psychological health primarily in the form of environmental stress resulting in depression, learned helplessness, abusive behaviors, etc. The World Health Organization defines health as a state of optimal physical, mental, and social well-being and not simply the lack of disease and infirmity. The human-environment relationship often is a casual factor in human health introducing biological and environmental sources of injury and physical or psychological reactions to stress which further accentuates the interrelationship between human health and design.

Stress is a response – either psychological or physiological – to a stimulus that offers exposure on a frequent basis to physical, social, or biological situations which influence or inform negative reactions that can accumulate causing physical ailment (Ulrich and Parsons, 1992, 98). The stressors may be external or internal. External stressors (also considered ambient stressors) include environmental stimuli such as noise, odor, temperature, crowding, or other extremes in stimuli while internal stressors encompass things such as conflict, disorganization, or violence. Consequently, they can be considered acute or chronic, with chronic stressors providing the more adverse health effects (Kopec, 2006, 101-102; Ulrich, 1992, 98). The stress itself is not the cause of injury or illness, rather the response to it reduces the efficiency of the immune system and causes negative health issues such as increase blood pressure, ulcer, heart attack, and migraine headaches. Aside from physical responses to stress, there are also behavioral responses such as withdrawal, aggression, irritability, and in certain cases violence and delusions. The physical and psychological effects of stressors almost always continue beyond the exposure to the stressor causing damage to our well-being and making it a critical issue when considering human-environment behavior.

One of the most commonly recognized stressful environments producing a wide variety of emotions, fears, and anxiety is that of a hospital or other healthcare settings. Patients' loss of independence and loss of psychological control in decision making and privacy can directly affect their involvement in the healing process and often creates

increased levels of stress that negatively affect their healing time. In addition to these stressors, fear of unknown outcomes and separation from family, especially for children, can also increase the stress of hospitalization. Concentration and pain management also decrease as stress from lack of control increases. Consequently, control is integral to the psychological health and stress management of all patient populations (Delvin and Arneill, 2003, 672; Kopec, 2006, 214). Stress does not just influence patients, but also greatly affects the healthcare staff, mainly nurses. Due to staff reductions, increasing job demands, lack of control, stress related to shift changes, and events such as patient death can all lead to burnout and fatigue. The push for patient-centered care in many facilities has led to compromised or elimination of staff spaces needed for restoration, socialization, and support. The contribution of stress from these factors can directly influence the level of care the nurse is able to administer and can result in increases in medical error and decreases in patient health (Marcus and Barnes, 1999, 32-33). Research of stress in healthcare settings for patients and staff has opened the doors for reform and continues to identify psychological responses to stress as having an effect on medical outcomes and recovery time. Psychological interventions have become one of the primary means to reduce stress within the healthcare environment, and the use of nature has received the most notice for having psychological benefits for managing stress (Marcus and Barnes, 1999, 32; Vincent, 2009, 41).

Psychological Benefits of Nearby Nature

The natural environment exhibits a unique set of psychological benefits and becomes an important factor in human-environmental relationships, well-being, and stress reduction. The famous American landscape architect F.L. Olmsted is notorious for his belief in the restorative psychosocial value of nearby nature:

> Nature employs the mind without fatigue and yet exercises it; tranquilizes it and yet enlivens it; and thus, through the influence of the mind over the body, gives the effect of refreshing rest and reinvigoration to the whole system (Olmsted, 1865; Park, 2006, 12).

Many of the environmental psychology theories discussed previously support and further explain Olmsted's statement. For example, he speaks of the restorative properties of the natural environment which can be viewed in the framework of the affordance theory reinforcing the connectedness concept of nature (Kaplan, S, 1992, 138). Restoration is defined as a positive shift of cognitive, physical, and social functioning which is influenced by the affordance of the setting (Said and Baker, 2007-2008, 19). Next, the learning theory explains our response to nature and plants as one that is learned through our positive experiences we have with natural environments during vacations, recreational and leisure activities, as well as culture and social significance given to natural environments or objects found within them (e.g., grass lawns). One of the interesting issues when considering the broad category of nature and this theory is the fact that people from different geographical regions and cultural experiences have similar preferences for natural settings and the density or type of plants within them as well as the belief in the restorative value of nature (Kaplan, R., 1992, 125; Park, 2006, 7; Ulrich and Parsons, 1992, 95).

Categorized as a stimulation theory, attention restoration theory gives emphasis to accessible nature and plants as a means of maintaining or restoring attention. One of the key concepts of the theory is that of involuntary attention in restoring the psyche. Kaplan emphasized that nature is one of the most captivating objects capable of holding attention, providing a break from directed attention, and treating mental fatigue (Park, 2006, 11-12; Ulrich and Parson, 95; Vincent, 2009, 47). He also outlines four components that contribute to a restorative environment:

1. Being Away: a preferred natural setting for getting away from the source of fatigue and for being able to rest one's directed attention.
2. Extent: the physical or conceptual feeling of being in a "whole different world" brought about by connectedness, scope, or miniaturization of the larger landscape.

3. Fascination: objects that request effortless or involuntary attention, but are still perceived as fascinating (e.g., clouds, sunset, leaves moving in a breeze)
4. Compatibility: the agreement between human inclinations and the natural setting to create an environment that requires less effort or directed attention (Kaplan, S., 1992, 138-139; Vincent, 2009, 50-51).

The Kaplans' research regarding human-environment relationships in nature extends beyond their theories of preferences and restoration to the psychological benefits of nearby nature and the level of connectedness to it. Rachel Kaplan describes nearby nature as proximal vegetation from a single street tree, or a potted herb on a sill, to arboretums and fields and woods. She goes on to state that nearby nature can be interior or exterior, and even when it is exterior, it can be viewed from the interior (1992, 126). A broader definition encompassing concepts from the professions of landscape architecture, horticulture, and botany is proposed to evaluate how people experience the natural environment and their resultant behaviors and benefits derived from this exposure. Perception plays a critical role in how people see the natural environment. Professionals will see a plant or nature in a manner that is characteristic of their learned vocabulary and expertise causing them to recognize and categorize the subject easily assuming that their perception is similar to others. However, their perception prior to their training would be obviously different and based on their knowledge and situation at that given time. Routine exposure also plays a role in how we categorize and recognize natural stimuli and how readily we assume our perception is shared. All of these concepts are explored further using Kaplans' preference framework, by analyzing the pattern of these categorizations, revealing the natural settings that people favor, and how they are experienced (Kaplan, R., 1992, 126; Vincent, 2009, 47-48).

The resulting research reveals that specific plants are not of major significance to people as they are not the major focus of their human-environment experience; however, the presence of vegetation and the contact with it is important to the perception of the

natural setting and the amount and arrangement of these elements are integral to people's understanding of how the natural environment is categorized (Kaplan, R., 1992, 128; Ulrich and Parson, 1992, 97). The human experience in nature is broad, but these kinds of experiences and the subsequent benefits tend to share strong similarities making it beneficial to understand the role of nature in the human experience.

Much research on connection to nature discusses its benefit on human well-being (Kaplan, R., 1992; Kaplan, S.; 1992, Park, 2006; Simson, 1998, 26; Ulrich, 1984; Ulrich and Parsons, 1992; Vincent, 2009; Verges and Duffy, 2009, 626). In many cases, this benefit can be achieved from passive involvement and may not be fully utilized, but simply by knowing that the opportunity to connect with nature is available makes for increased satisfaction and well-being within an environment. A significant amount of evidence from psychological, emotional, and physiological changes shows the restorative benefits of nature scenes are displayed within three to five minutes of exposure (Ulrich and Parson, 1992, 100; Ulrich, 2002, 4). An excellent example of this concept comes from the level of satisfaction achieved from having a view of nature and much of the supporting research references examples of windowless spaces in hospitals, schools, or work environments as not being preferred. Several studies completed in healthcare settings show patient recovery time was drastically reduced for those that had windows in their rooms and were able to simply observe nature (as opposed to performing activities in nature). The opportunity to view nature is not only important for well-being or satisfaction in healthcare, but also plays an important role in work environments. In a 1988 study by the Kaplans, they found that a view of nature resulted in less job pressure, higher satisfaction rates, and lower reported headaches or illness compared to those employees who did not have a view to the outside or were able to only view built objects from their window (Kaplan, R., 1992, 129).

Although the concept of nearby nature has a fairly consistent psychological response, it is important to note that this is not an absolute, universal pattern. Perception

swayed by culture, society, experience, and life-cycle affect responses to natural environments and plants. It is necessary to identify the prevalence of the meaning of nature and to acknowledge the disparities on the topic (Ulrich and Parson, 1992, 95-96; Wagenaar, et. al., 2003, 32). Rachel Kaplan reiterates this importance by stating that, "Nature is not merely an amenity, luxury, frill or decoration. The availability of nearby nature meets an essential human need…" (1992, 132).

HEALING AND RESTORATIVE LANDSCAPE

Background

The fields of therapeutic horticulture and healing landscape architecture and design share a common goal of benefiting human well-being by increasing connection to nature. While the topic of healing and restorative landscape and horticulture has gained more popularity within the past 10-20 years, it is a subject that has a deeply rooted history. Some of the earliest examples of restorative gardens in Europe are from hospital and monasteries during the Middle Ages that provided cloister gardens filled with trees, flowers, herbs, and birds to allow for varying degrees of sensory exposure in a secure and hidden environment. The fourteenth and fifteenth centuries saw an increase in crop failures, plague, and population migration to cities as well as a decrease in monasticism all of which overwhelmed the existing facilities and lead to the decline in the significance of restorative gardens within these monasteries. Additionally, open spaces that had surrounded hospitals began to be developed by the growing amount of urban residents and the responsibility to care for the sick began to shift to civic and religious authorities. Many hospitals began to be designed in the Roman Catholic tradition of long wards with beds facing a central location where a priest would perform mass, and in the influential Ospedale Maggiore in Milan from 1458, the windows were so high that views to the formal garden were nonexistent (Marcus and Barnes, 1999, 10-11).

At the end of the eighteen century, hospital garden design recommendations were written by German horticulture theorist Christian Cay Lorenz Hirschfeld. He passionately discusses the benefits of connection and views to nature:

> A hospital should lie open, not encased by high walls. The garden should be directly connected to the hospital, or even more so, surround it. Because a view from the window into blooming and happy scenes will invigorate the patient, also a nearby garden encourages patients to take a walk…. The plantings, therefore, should wind along dry paths, which offer benches and chairs….A hospital garden should have everything to enjoy nature and to promote a healthy life. It should

> help forget weakness and worries, and encourage a positive outlook….The spaces between could have beautiful lawns and colorful flower beds….Noisy brooks could run through flowery fields, and happy waterfalls could reach your ear through shadowy bushes. Many plants with strengthening aromas could be grouped together. Many singing birds will be attracted by the shade, peace, and freedom. And their songs will rejoice many weak hearts (Marcus and Barnes, 1999, 11-12).

Hirschfeld's recommendations were informed and realized by many hospitals of the seventeenth and eighteenth centuries as scientific medicine emerged and was matched by the Romanticism movement that inspired the return of garden spaces for restoration and healing within the hospital grounds. Cross-ventilation became a central concept in disease control during this time and the design of hospitals responded by providing continuous colonnaded corridors with bed wards branching off and rooms with large windows to increase ventilation. This design became known as a pavilion hospital (Figure 1) and outdoor spaces were incorporated between the branches of the bed wards (Marcus and Barnes, 1999, 12-13). One of the most influential nurses responsible for much public health reform, Florence Nightingale (1820-1910), wrote about the wide adoption of pavilion hospitals with much zeal:

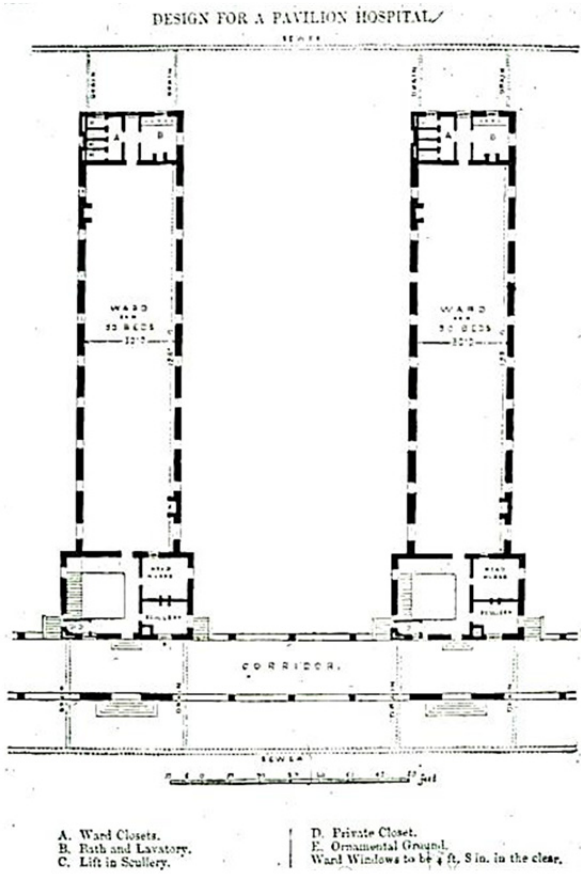

Figure 1: Example of a Nightingale Ward (Pavilion Hospital), from Notes on Hospitals, Florence Nightingale (Barach, and Dickerman, 2012).

> Second only to fresh air…I should be inclined to rank light in importance for the sick. Direct sunlight, not only daylight, is necessary for speedy recovery….I mention from experience, as quite perceptible in promoting recovery, the being able to see out of a window, instead of looking against a dead wall; the bright colors of flowers; the being able to read in bed by the light of the window close to my bed-head. It is generally said the effect is upon the mind. Perhaps so, but it is not less so upon the body on that account (Marcus and Barnes, 1999, 13).

The level of healthcare reform did not just apply to general hospitals during the late eighteenth and early nineteenth centuries, but also applied to the treatment and design of psychiatric patients and the hospitals that treated them. A nurturing, holistic approach was now applied to the care of patients, and therapeutic horticulture and protected landscaped grounds became integral to the treatment programs and for psychiatric well-being (Marcus and Barnes, 1999, 13).

As with all areas of advancement in the twentieth century, efficiency and profit was sought after in medical science, communication, construction, and just about every other technical aspect of our society. This shift pushed for more efficient hospitals and with advancements in technology, such as the introduction of the elevator and high-rise construction, low-rise pavilion hospitals and complexes began to be replaced by more institutional looking structures. This shift also strove to make the environment more efficient for doctors and nurses and less and less attention was given to the patient experience. Gardens were replaced with parking lots; balconies were abandoned as building skins became more and more enclosed with advancements in heating and cooling; and urban teaching hospitals began to set the precedent for the styles that were replicated elsewhere (Marcus, 2007, 1; Marcus and Barnes, 1999, 13-14). Insurance companies pressured healthcare facilities to minimize the patients' stay and did not offer any reimbursements or incentives for usable garden space and by the late twentieth century, the healthcare garden was an ignored restorative amenity which had been replaced by technology and medicine (Larson, 2004, 1).

The ignoring of the garden within a healthcare environment may be believed to be comparable to the neglected psychological well-being in the treatment of illness in the last century as the benefit of nature had not been scientifically proven or easily quantified. Facilities focused on technology and the healing environment became institutional, sterile, and stressful. As healthcare institutions become more and more competitive and with the rising cost of healthcare, an interest in alternative and complementary medicine is being explored. Institutions such as The Joint Commission for the Accreditation of Hospital Organizations (JCAHO) stated in 1999 that "patients and visitors should have opportunities to connect with nature through outside spaces, plants, indoor atriums, and views from windows" (Larson, 2004, 2). The environment is now recognized as being a tool to support healing by reducing stress and anxiety, lowering blood pressure, and reducing length of stay, and more design professionals are responding to the research and demands for patient-centered care, including supportive environments for staff and visitors, and are reintroducing gardens into healthcare settings for therapeutic purposes on an international basis (Marcus, 2007, 2; Marcus and Barnes, 1999, 17, 27-28).

Theory of Supportive Gardens

The scientific research related to stress currently contributes to the development of a theory of supportive garden design that hypothesizes the link between health outcomes and environmental design features and stimuli. The primary supportive function of these spaces is stress mitigation for patients, staff, and visitors causing them to be a viable addition or alternative to medicine and treatment influencing overall well-being (Marcus and Barnes, 1999, 35). To truly design gardens that have the capability to heal and act as supportive environments in a healthcare setting, it is critical to understand the behavioral association between the physical environment (physical, cultural, and social) and the users (Tyson, 1998, 14-15). Based on many of the behavioral theories presented in the previous section as well as research on gardens, the importance of

gardens in a healthcare setting is derived from the stress relieving benefits for staff, patients, and visitors in the form of:

1. Providing a sense of control and privacy
2. Social support
3. Opportunities for physical exercise and movement
4. Positive distractions and connection to nature

Lastly, in order for the space to function effectively and to be utilized, it must be perceived as secure. If not, the garden may actually become a stressor and patients, staff, and visitors will most likely avoid the space due to their sensitivity to environmental cues (Marcus, 2007, 6; Marcus and Barnes, 1999, 36).

Based on a great deal of environmental research from various settings, a sense of control is a vital element influencing a person's ability to deal with stress, especially stress related to an illness or hospitalization. Control in a healthcare setting is usually compromised as a patient loses their ability to determine their activities, situations, and degree of assistance contributing to real or perceived loss of control which often causes stress. As healthcare providers and designers become increasingly aware of this issue, attempts are being made to provide opportunities for the patient to have (or perceive they have) control, and gardens are being designed with this stress-reducing feature in mind (Marcus and Barnes, 1999, 37-38; Ulrich, 2001, 54). However, there remains a lack of research looking specifically at control in garden environments, so the supporting research looks at the stress-reducing and restorative benefits of gardens and incorporates elements of control from other environmental behavior research (Marcus and Barnes, 1999, 39-41; Ulrich, 2002, 7).

Some of the most basic elements of control dealing with healthcare gardens have to do with accessibility and way-finding. The patients, staff, and visitors must know that

the garden exists, be able to navigate to and from the garden without difficulty, and be able to choose the level of passive or active engagement they will have while there. If the garden is difficult to find or the accessibility is problematic, the loss of control related to the environment can become more of a stressor than a restorative experience. Wheelchair access into and around the garden as well as proximity to patient areas will increase use by patient and visitor populations (Mitchell, 2011). In general, the garden will be utilized more effectively if it is adjacent to interior spaces used by patients, visitors, and staff such as major corridors or cafeterias. In addition to accessibility, privacy within the garden and visual privacy with respect to windows overlooking the garden will assist in fostering control. Providing a variety of spaces, seating, and exposure will also allow the user to have choices reinstating an aspect of control that may have been compromised with hospitalization. Some facilities with more long-term patient populations may also consider involving the staff and patients in the gardening process further increasing feelings of control (Marcus and Barnes, 1999, 41-42).

Another important property of supportive gardens is their ability to offer social and emotional support for patients, visitors, and staff. Much research has found that people's health and well-being tend to benefit from social contacts and encouragement, and like much medical research, the exact reasons for the connection is not completely understood other than through the reduction of stress. The translation of this research to the interior design of the environment has manifested itself in space and furniture accommodations for visitors in the patient room and increased waiting areas adjacent to patient areas. In the case of healthcare gardens, there is a continued lack of empirical research documenting the social support benefits derived by patients in a garden setting, however, other research points toward parks and gardens as being important settings for social interaction (Marcus and Barnes, 1999, 42-43; Ulrich, 2001, 54). One study has provided evidence that these settings are important for patients, visitors, and staff to access social support and that a large majority of the users actively engaged in some form of social interaction. Claire Cooper Marcus and Marni Barnes conducted a study of four

California healthcare gardens in 1995 and discovered that 73 percent of the users engaged in at least one conversation with another user. Of those interviewed, 36 percent also stated that they had used the space to socialize with a patient, while the majority of the staff reported using the garden to interact with other employees (Marcus and Barnes, 1999, 44). In the case of this study, further research is needed to determine if these social interactions did indeed provide health benefits for the participants.

When considering the design of gardens for social support, it is again important to allow access to these environments by patients, staff, and visitors. The provision of zones within a garden that allow for smaller groups to gather will accommodate increased social support. In some cultures, larger or more extended family is involved in the patient care, so a setting that still provides a sense of privacy for a slightly larger group may be important to incorporate as well. The goal of the garden should be to promote social interaction without compromising the users' access to privacy. Gardens that are crowded and perceived as hectic will have negative psychological effects and the environment can become stressful. In several studies, patients and staff have been cited as saying they prefer "natural, spatially enclosed settings for active socialization" and "natural, spatially open settings for more passive and often private activities" (Marcus and Barnes, 1999, 45-46). Similar research also concluded that the majority of people that use healthcare gardens do so as an escape from the interior environment and in search of privacy and to be alone(Marcus and Barnes, 1999, 46; Ulrich, 2001, 54-55).

Directly associated with health and well-being is that of physical movement and exercise. In addition to the health benefits associated with physical activity, there are also psychological and emotional benefits related to combating stress. The addition of a garden in a healthcare environment can easily support the research that shows the benefits of exercise on patient populations and in the improvement of health outcomes. Depression is also a common result of hospitalization, especially in long-term situations or for the chronically ill. There is also strong research that directly relates exercise, both

aerobic and nonaerobic to be effective in the reduction of depression, suggesting that regular exercise is effective as a form of psychotherapy making the case for patient-accessible gardens even more relevant (Marcus and Barnes, 1999, 47).

One of the primary ways in which exercise or physical activity in a garden can be increased is by siting and designing the garden to be a destination. Separate from the restorative properties of nature which is achieved through visual and auditory cues, nature and gardens are thought of as much more pleasant and attractive than the majority of the interior of healthcare environments (Marcus and Barnes, 1999, 72). Atrium gardens or dramatic views from a window can also offer destination points that will require trips down corridors promoting movement. This is a successful design approach for climates that have extreme summers and winters and will allow the building occupants to maintain connection and, where feasible, access to nature. Rehabilitation spaces would also benefit from adjacency to a garden where views could be maintained and walking loops could be incorporated for more able patients, visitors, and staff (Marcus and Barnes, 1999, 48).

Lastly, an important role in stress reduction is that of a positive distraction in the form of a natural element which may create an improved psychological and emotional response and help to reduce stress. Positive distractions are not merely effective for patient populations, but also benefit staff and visitors who also incur environmental stress. Some of the well-received examples of positive distractions within a healthcare environment are laughter and comedy, companion animals and pet therapy, art, music, and nature (Marcus and Barnes, 1999, 49; Ulrich, 2001, 55). If art is being considered for a garden environment, it is critical to understand the patient's perspective and the fact that abstract art may have the opposite effect and can actually cause increased levels of stress in patients. Research indicates that ambiguous environmental stimuli, such as art, can affect a viewer's perception and response which is influenced by their emotional status. This concept of emotional congruence proposes that viewers will most likely

focus on a subset of stimuli that matches their emotional state meaning that artwork may be experienced differently by the designer, staff, visitors, and patients and should be selected with extreme care to ensure it is a positive distraction (Marcus and Barnes, 1999, 66; Ulrich, 2002, 8). Overall, the exposure of stress reducing elements and situations within a well-designed healthcare garden are enhanced by the supportive and restorative environment that increased connection to nature (Burnett, 2003, 21).

Healing Gardens

Nature fascinates and invites our attention without causing physical or mental fatigue. It can restore the mind, reduce stress, awaken the senses, and cause a person to reflect on their own healing (Marcus, 2007, 8). The term "healing" has a broad usage and typically refers to a process that promotes overall well-being. By looking at three aspects of healing within a healthcare setting, we can begin to identify how a garden environment may also be therapeutic and assist in the healing process. The first characteristic is the element that is being described as "healing" or "therapeutic" assists in achieving a degree of relief or awareness of physical symptoms playing a significant part in pain management and treatment processes for patients with chronic or acute illness. Next, healing can be in the form of stress reduction and increased comfort for someone experiencing the psychological or physical effects of a healthcare environment. As discussed in the previous section, this aspect is a critical contributor to well-being and extends to the patient, staff, and visitors. The first two components support the third concept which is that of assisting in an improvement in the overall sense of well-being and optimism experienced by an individual and, in turn, supports physical improvements. As discussed, the physical environment can greatly influence response, impact well-being, and support the healing process (Marcus and Barnes, 1999, 3; Ulrich, 2001, 56; Wagenaar, et. al., 2003, 31).

There are a number of reasons that gardens can be considered healing or therapeutic, and the most obvious is the verdant environment that they create and the

aesthetics of the natural world that draws people outdoors. The sensory stimuli introduced by being out in the sun, observing trees, flowers, and birds, hearing these birds and sounds of water or wind in the trees create positive distractions and is beneficial in reducing stress. In order for a garden to be healing beyond the passive experience of simply viewing it from the interior, it needs to consider design features that encourage people to go outside. By providing features that allow for physical activities such as walking or more vigorous exercise and by offering choices for the user to choose the level of sun or shade exposure, socialization, and privacy, a garden can provide healing benefits beyond the architectural walls of the healthcare building (Larson, 2004, 3; Marcus, 2007; 8-9; Marcus and Barnes, 1999, 4). In several studies, 95 percent of the users in healthcare gardens or outdoor spaces reported feeling less anxious, stressed, or depressed after spending time in these settings. More than two-thirds cited plant materials and visual cues (trees, greenery, flowers, colors, seasonal changes) and more than half mentioned other stimuli such as fragrances, birdsong, and the sound of running water as being the elements or characteristics that led them to this change in mood. The researchers concluded that it was the natural elements that contrasted with the interior environment that supported the calming or restorative process in a healthcare setting (Marcus and Barnes, 1999, 5, 8; Ulrich and Parson, 1992, 95; Wagenaar, et. al., 2003, 31).

Healing gardens are both a place and process coalescing design and medicine. It is important to remember that the garden cannot cure, that it may not be effective for every user or at all times, but in general, it can greatly assist in the healing process and provide therapeutic support (Marcus, 2007, 22; Wagenaar, 2003, 34). A significant term to consider in the context of a healing environment is that of a health outcome, i.e., a measurable indicator of the patient's progress or condition. Health outcomes may be physical or psychological and can be self-reported or measured. They can range from clinical indicators such as blood-pressure, depression, pain, medication intake, and length of stay to reported outcomes dealing with satisfaction, etc. (Ulrich, 2002, 3). The use of

outcome studies in healthcare is not a new concept, and they are crucial in providing a widely accepted framework for evaluating effectiveness of medicines and treatment processes, as well as gauging costs and expenses. Outcome studies have the potential to be useful and influential in the evaluation of the effectiveness of garden environments and how they may influence medical and health outcomes (Marcus and Barnes, 1999, 30-31).

Horticulture as Therapy

While healing gardens are typically designed to promote an increase in overall well-being incorporating psychological and physical response, therapeutic gardens and landscape design relates to a specific aspect of a disease or needs of a given group of people for the healing process and to maximum cognitive, social, physical and psychological functioning. It is typically incorporated into the treatment programs of horticulture therapy, and the results and outcomes are documented and measured during activities taking place in the therapeutic environment (Haller and Kramer, 2006, 5; Larson, 2004, 3). A broader definition of horticulture encompasses the therapeutic benefits of the field: "the art of growing flowers, fruits, vegetables, tress, and shrubs resulting in the development of the minds and emotions of individuals, the enrichment and health of communities, and the integration of the 'garden' in the breadth of modern civilization" (Simson, 1998, 21-22).

The physiological and psychological responses to plants have been discussed in detail in previous sections, and it is the supporting science from these theories that have helped inform and provide a framework of evaluation for the human-environment relationship in regards to plants and horticulture. Many of the techniques and processes used in the fields of psychology, occupational therapy, social work, and education have been adopted by horticulture therapists. The therapist typically works with or co-treats along with a medical professional to optimize therapeutic approaches. The American Horticulture Therapy Association (AHTA) is working towards more empirical research,

standards for practice, and a more rigorous credentialing system to increase exposure and advocacy for the field among healthcare providers and insurance and policy regulators (Haller and Kramer, 2006, 1-4).

Therapeutic horticulture programs commonly use gardens where growing, harvesting, processing, experiencing, and observing of plant material reinforces and inspires positive responses in patients, visitors, and staff in hospitals, clinics, long-term care facilities, etc. The unique value of such programs is being identified and the quality and quantity of programs is increasing in healthcare settings (Simson, 1998, 287). These therapeutic gardens provide a location for therapists to engage with patient population and others to experience horticulture stimuli that are relevant to the specific needs of the user in regards to their healing process. These gardens are designed to utilize plant material to achieve any of several goals:

1. Support clinical therapy through sub-spaces to accommodate different sized groups and needs for private or group activity. Containers and in-ground accommodations for plantings are needed to support the therapy.
2. Empower users by inspiring new skills, understanding, and confidence through interactions with horticulture.
3. Highlight the restorative characteristics that make the garden an environment for recovery, rest, and pleasure.
4. Offer a pleasing, informal landscaped amenity for visitors and staff (Simson, 1998, 287-288).

Apart from the goals for the garden, a universally designed space and related therapy programs can promote a variety of experiences such as opportunities for socialization during activities or classes, tasks involving the cultivation of plant material in a living environment, and new learning experiences for patients, staff, and visitors. In addition to outdoor garden spaces, interior spaces have successfully been utilized for

projects such as floral design or plant propagation (Simson, 1998, 288, 317). The indoor and outdoor activities provide a high level of stimuli and challenges more aligned with what the patient will experience once they return home, and provide an opportunity to look past physical limitations by utilizing many different skills (physical, social, and mental) concurrently while dealing with the plant-related task (Chambers, 2009).

Therapeutic horticulture is often used as a tool to help develop or rehabilitate cognitive functioning. The natural world offers affordances that are engaging and stimulating assisting in simple identification and basic classifications among natural and living items such as trees, plants, flowers, birds, insects, etc. By observing and experiencing the rich details in nature, cognitive development is fostered through analysis, integration, interpretation, and understanding of ideas or facts. As exposure to these natural elements continues, improvements in concentration and attention capacity are identified as well as increased critical thinking and application of concepts to other situations outside of the therapeutic or natural environment. Memory is also stimulated by exposure to nature and the patient begins to recall or recognize underlying relationships and patterns by carefully understanding influences and results of interactions with nature (Hartig, Mang, Evans, 1991; Herzog, Black, Fountaine and Knotts, 1997; Kaplan and Kaplan, 1989; Kellert, 2005, 67-70; Ulrich and Parsons, 1992).

Types of Outdoor Spaces

Landscape architects now have the difficult task of mediating between the real environment, the perceived environment, and the observed environment to design therapeutic spaces that create a place and support a process (Marcus and Barnes, 1999, 87, 89). This assignment requires a common vocabulary, increased interdisciplinary teamwork, and a specific set of design considerations. In order to arrive at this goal, it is important to gain an overview of different types of outdoor spaces. The typologies, advantages, and disadvantages of these outdoor spaces represented in Appendix A are

from the research completed by Marcus and Barnes between the years of 1995 to 1998 in the United States, Australia, Canada, and England (1999, 115-152).

Design Patterns and Guidelines

In addition to understanding the types of outdoor spaces, it is important to understand design patterns or guidelines that are recommended in the formation of these spaces. Patterns, in this situation, refer to an occurrence that has taken place repeatedly in an environment. Patterns tend to be deeply rooted in the language of design and can define a setting and help form our perception of the environment (Tyson, 1998, 43). Observation of human behavioral response to an environment is a key factor when considering patterns. Christopher Alexander and coauthors presented 253 patterns in his 1977 book, *A Pattern Language,* that have become the basis for a universal design language for creating spaces at all scales that address the relationship between humans and their environment. Martha M. Tyson took 25 of these patterns as a basis for her own pattern hypothesis in her 1998 book *The Healing Landscape: Therapeutic Outdoor Environments.* For example, Alexander's pattern number 106, "Positive Outdoor Space" is described as follows:

> Make all the outdoor spaces which surround and lie between your buildings positive. Give each one some degree of enclosure; surround each space with wings of buildings, trees, hedges, fences, arcades, and trellised walks, until it becomes an entity with a positive quality and does not spill out indefinitely around corners (Alexander, et. al., 1977, 522).

Tyson then goes on to illustrate examples and provide specific objectives for this pattern hypothesis for healing landscape related to "Positive Outdoor Space." She starts by listing the "Individual's Needs: Provide for safety and security; Allow for heightened sensory awareness," continues with "Physical Environment: Create comfortable microclimate; Provide interesting walking paths," and finishes with "Behavior: Maximize spatial orientation; Encourage social and environmental interaction" (Tyson, 1998, 45). Proposed design patterns and subpatterns from Tyson's research are outlined in

Appendices B and C (Tyson, 1998, 61-64). The intention of the patterns and guidelines is not to hinder or restrict creativity, but rather to assist in the design process of healing landscapes recognizing that healthcare situations may not be the most appropriate locations to test innovative or unprecedented solutions.

EVIDENCE-BASED HEALTHCARE DESIGN

Background

As much of the research in Environmental Psychology and in healing landscapes has concentrated on the adaptation and reaction of humans to the natural environment, the research that contributes to healing architecture also relies on similar principles of behavioral responses to the built environment establishing the basis for evidence-based healthcare design. Considerations, patterns, and guidelines derived from research regarding healing natural environments can be applied to the design of the built environment to increase its restorative value. While these disciplines focus on the experience of the user, the role of architecture in the healing process becomes a significant factor in need of continued empirical research as healthcare needs and concerns constantly evolve.

The healthcare building boom over the past ten years has been in response to keeping up with changing demographics, technological advancements, economic pressures, and rising competition – all of which will shape the healthcare environment for the next generation. The public is increasingly informed on issues in the healthcare sector as a result of proposed political reforms and reports such as the Institute of Medicine's *Quality Chasm* series that is highlighting the need for considerable improvements in the quality of care, the reduction in nursing turnover rates, decreased hospital acquired infections, as well as increased safety and focus on patients and their families (Cama, 2009, Vii, 5; Ulrich, 2002, 6; Ulrich and Zimring, 2004, 3-4; Zimring and Bosch, 2008, 147). The increase in construction creates an urgent need to better understand the built environment's effect on healing for patients, staff, and visitors. A growing number of scientific studies are being reported that support the impact of design on medical outcomes within the context of healthcare and can be found in peer-reviewed journals from the fields of medicine, nursing, architecture, environmental psychology, and others (Cama, 2009, Viii).

The medical community is progressively shifting toward a model known as evidence-based medicine utilizing systematic reviews of literature that evaluate research to support or inform clinical choices. The healthcare design industry is following suit by using human-environmental research to inform design decisions known as evidence-based healthcare design which requires a new practice model replacing philosophy with empirical evidence (Levin, 2011, 1; Wagenaar, et. al. 2003, 15-16; Zimring and Bosch, 2008, 147-148). However, the implementation of this growing amount of evidence creates a challenge for architecture and design fields which are traditionally not research based and are even less unaccustomed to creating, judging, and sharing research as they tend to focus on the product as opposed to the process (Delvin and Arneill, 2003, 667-668).

Building the Evidence for Evidence-based Design

Evidence-based healthcare design can potentially help make healthcare environments more pleasant, safer, therapeutic, and more supportive for patients and families as well as for staff performance. In order to inform design decisions, continued empirical research and the dissemination of the body of knowledge needs to be a priority. A concise definition of Evidence-based design is provided by The Center for Health Design as "the deliberate attempt to base building decisions on the best available research evidence with the goal of improving outcomes and of continuing to monitor the success or failure for subsequent decision-making" (Hamilton, 2003, 1; Malkin, 2008, 2). This "best available research" may be in the form of evidence from the field or an organization and will require analysis to begin to inform a design hypothesis that is based on behavioral, economic, or organizational clues that can produce a repeatable, beneficial physical or psychological outcome. This hypothesis is not prescriptive, but begins to inform innovative approaches to a design decision that can be tested and documented to increase the related body of knowledge (Cama, 2009, 7, 10).

The research methods and study design for data collection in healthcare environments are similar to approaches in other fields of study, but one of the factors to consider with healthcare is that patients are already subjected to a variety of examinations and outcome reporting that can contribute to human-environmental research reflecting medicine intake, length of stay, stress, and satisfaction. As with all patient-related information, privacy measurements (i.e., HIPPA) can restrict much of these results if proper measures and consent are not obtained in advance. One of the first methods for conducting research is through observation including observing physical traces or environmental behavior. By analyzing physical traces, the researcher can study indications of previous use or activity, rather than activities that may have just been produced for the research, allowing them to understand the pattern of use over a period of time. By observing environmental behavior, the researcher can understand how individuals and groups react to and use a space to determine if the environment supports or prompts the resultant behaviors. Several other methods include the use of focused interviews or standardized questionnaires that can offer insight into more psychological responses or perceptions of an environment (Malkin, 2008, 24-25). A practical, on-going example of this is the patient satisfaction surveys that are taken at the end of a hospital stay. If applicable or capable of being amended, questions pertaining to environmental response may be included in these forms. For this research to be valuable and applicable to design solutions, it needs to consider some key components. The first is that it needs to define the audience such as nurses, patients, visitors, etc. The next is that it has variables that are related to the audience like nursing turnover rate, length of stay, or pain medicine intake. An additional key component of impactful research is that it needs to have the findings published in a credible format, whether as conference presentation or in a peer-reviewed journal. Finally, it needs to identify and prioritize design interventions that influence the audiences' behavior (Watkins, 2008, 5-6).

One of the difficulties and points of criticism of evidence-based design is how to determine the credibility of the evidence within a quickly growing body of knowledge. Traditionally, the majority of the scientific evidence that is available to the design

profession deals with human-environment relationships from the interdisciplinary field of environmental psychology, but an increasing number of studies from the fields of Neuroscience, Psychoneuroimmunology (the study of social, psychological, and behavior interactions in the brain, endocrine and immune systems), and evolutionary biology (e.g., Biophilia) have begun to emerge (Cama, 2009, 34). In review of research from any of these fields, it is crucial to determine the internal validity of a study and how it uses quantitative data to help rule out alternative factors that could have contributed to the response. As is the case with evidence-based medicine, studies utilizing this methodology possess more empirical strength and stronger evidence (Pati, 2011, 1, 3). Likewise, systematic reviews and meta-analysis of a specific question within multiple studies or related fields are considered more credible than review of a single study and are useful to help inform evidence. Literature reviews are useful for evaluating the current state of evidence, but may not provide the level of integration needed to translate the evidence to a design solution (Pati, 2011, 6-7).

By having such a systematic approach to evaluating behavior or environmental factors to inform design decisions, it is common for designers to feel that the process may inhibit their creativity. One of the original contributors to the theory of evidence-based design, Kevin Hamilton argues that this challenge in fact calls for "an exceptionally creative and ever-changing interpretation of new data...encouraging designers to test new and interesting ideas" (2003, 1). The designer is then called to observe the effects of the design and implement what has been learned into forthcoming projects – a critical component of evidence-based design (Martin, 2009, 1-2). For many designers, the term "evidence-based design" is used as a trendy marketing term touted in trade publications and at conferences. It is important for more designers within the profession to fully understand the definition, goals, process, and most importantly how to implement evidence-based design into practice. The development of this knowledge, the implementation, testing, and reporting of design decisions will assist in growing the related body of knowledge that supports the evidence (Martin, 2009, 7).

Data collection typically takes place during the programming or pre-design phases or during a post-occupancy evaluation (POE) of a project, so it seems natural for designers and project managers to struggle with how to implement the various phases of evidence-based design throughout the entire length of the project. An applicable approach is the use of semantics to move from the research process to the creation of design hypotheses (i.e., design intention). The hypothesis is the initial theory regarding the relationship between the design decision and the anticipated outcome that can serve as framework for further measurement and analysis (Cama, 2009, 123). Architectural and interior design processes typically begin in the Schematic Design phase after data has been gathered and evaluated, and project goals have been established, and team members begin to work together and join the team as needed to meet all of the project, client, economical, and schedule requirements. For projects practicing evidence-based design it is important to have these design hypotheses in place at the end of the schematic design phase. This will allow the project team to identify additional research needs or data collection for a successful study and any additional team members that may need to be added to support or measure specific hypotheses (Cama, 2009, 129). As design of the project continues to move forward, the team will continue to facilitate the innovative design hypotheses that can be tested and proved or disapproved first in a mock-up (off-site or live) and then, if appropriate, introduced into the new construction. Finally, the most important component in the evidence-based design process is sharing these design hypotheses and the measured outcomes in peer-review journals to inspire further exploration and to determine a broader acceptance or rejection of the design hypothesis (Cama, 2009, 14-15, 18, 43).

Architecture as Medicine

> Little as we know about the way in which we are affected by form, by colour, and light, we do know this, that they have an actual physical effect - Florence Nightingale (*Notes of Nursing,* 1859, p. 34)

Architecture and design are almost always thought of as an art whose success or acceptance is subjective. A well-designed building can be identified as being aesthetically pleasing, functional, and efficient, but apart from physical spatial qualities the effect of the specific environment on occupant behavior is rarely studied. This is beginning to change, however, as the Pebble Project supported by The Center for Health Design begins to study how specific healthcare environments that have been constructed using evidence-based design methods affect an occupant's behavior, and healthcare professionals understand that supportive design can facilitate recovery and shorten hospital stays (Delvin and Arneill, 2003, 666). This is beginning to close the gap between art and science in the field of healthcare design. Science fields rely on systematic experimentation and observation to study the physical world, and by creating a design with a measurable outcome, the built environment fits into the domain of science (Cama, 2009, 3-4). Applying this concept to healthcare environments, research primarily from environmental psychology can assist in creating components of the ideal built environment that are:

1. Easily accessible and useful
2. Encouraging for a sense of well-being
3. Supportive of connections to and among staff
4. Private and confidential
5. Caring for families and visitors
6. Sympathetic to deficiencies or impairments
7. Connected to nature
8. Secure and safe (Cama, 2009, 69).

If we begin to look at the science supporting evidence-based healthcare design, we can begin to understand how the built environment starts to influence medical outcomes. *The Lancet,* an international medical journal, proposes that evidence-based medicine now has its architectural counterpart in evidence-based healthcare design

encompassing the exterior and even more enthusiastically in the interior. Like evidence-based medicine, the focus of evidence-based design is not as much on the product, but assessment and evaluations of the experiences and processes that were promoted along the way to produce that outcome (Wagenaar et. al., 2003, 23; Ulrich, 2001, 49). Medical researchers at John Hopkins were initially skeptical about the link between architecture and health outcomes, but have determined that "about 75 percent of the most rigorous scientific studies in the area of Evidence-based Design have reported positive findings" meaning those studies strongly support a link between health outcome and architectural elements of the healthcare environment (30 percent is the usual success rate) (Wagenaar, et. al., 2003, 24).

These findings are generally focused on the environmental conditions or situations that facilitate well-being by providing social support, nurture control, and provide positive distractions primarily through connection and access to nature causing these to be important considerations in the design of healthcare facilities (Ulrich, 1992, 99; Ulrich, 2001, 49). All of these are important components that assist in the reduction of stress, which as we have seen with the reviews of the other bodies of knowledge, is a central function in human well-being. Again, stress is a prevailing issue for patient populations, staff, and visitors and efforts to alleviate stress are at the forefront of clinical goals based on the proven negative physical, behavioral, and psychological effects it can have on health outcome and general well-being. Psychologically supportive healthcare environments look at ways to reduce these environmental stressors and to include environmental features that are shown to reduce stress, provide control and privacy, encourage social interactions and support, and introduce connection and access to nature all in an effort to positively influence the healing process (Ulrich, 1992, 97-103; Ulrich, 2001, 54).

In addition to psychological effects of the built healthcare environment, there has been increasing research focused on concerns of sick building syndrome, indoor air

quality, and infection control. Groups such as the US Centers for Disease Control and Prevention (CDC) and the Healthcare Infection Control Practices Advisory Committee (HICPAC) have released guidelines and continue to regulate the built environment in efforts to reduce hospital acquired infections that are typically transmitted through airborne, droplet, and contact paths (Malkin, 2008, 40-41). Much of the research focuses on air quality, ventilation, and filtration systems and the direct role they can have on the concentrations of pathogens, particles, or fungi spores effecting infection occurrence as well as other health outcomes. Construction and renovation activities, which are more common than not in the ever-evolving healthcare environment, can be a culprit for reduced air quality and increased particulate matter providing a source for airborne infection transmission if proper measures and controls are not in place (Ulrich, 2001, 53; Ulrich and Zimring, 2004, 7). American Institute of Architects (AIA) is among one group that sets guidelines for healthcare spaces and addresses issues of supply and return air in isolation rooms (positive and negative), laminar flow in operating suites and clean rooms, and addition spaces that may house infectious or immunocompromised patients. Groups such as CDC and HICPAC suggest HEPA filters for healthcare facilities as opposed to standard 90 percent efficiency filters, but not regulate them for construction or renovation zones (Malkin, 2008, 53; Ulrich and Zimring, 2004, 7-8). In addition to the research on airborne infection, research has also been conducted on the benefits of single-occupancy patient rooms and increased hand washing which has also lead to changes in design guidelines and evidence towards the reduction in infection rates associated with droplet and contact transmission (Ulrich and Zimring, 2004, 6).

Another one of the most important aspects of the interior built environment that affects patients, staff, and visitors is day-lighting and artificial light. Appropriate exposure to day-light is essential in the support of circadian rhythms and biological well-being (Malkin, 2008, 63). Research across all building types has identified the benefits of day-light on productivity, job satisfaction, and absentee rates as well as in the reduction of stress, fatigue, and depression (Delvin and Arneill, 2003, 681; Smith, 2007b,

4;Ulrich and Zimring, 2004, 20). Thoughtful artificial lighting schemes and sun and day-light controls are especially important in healthcare settings as lighting transitions, light levels, color, and glare from light can become an environmental stressor.

Although the benefits of connection to nature on well-being have been discussed in detail in previous sections, it is important to mention it in the context of evidence-based healthcare design. An increasing amount of research is growing on the benefit of artwork (printed and digital) depicting realistic natural scenes not only as a positive distraction, but also to simulate the benefits of connection to nature in patient spaces and treatment rooms, staff spaces, and visitor waiting. The psychological responses have been significantly similar to studies that have used actual natural settings or views onto them showing reduced anxiety, decreases in pain medicine intake, blood pressure and heart rate, and reduced length of stay (Figure 2) (Delvin and Arneill, 2003, 682; Malkin, 2004, 70-71; Ulrich and Zimring, 2004, 21).

Figure 2: The Sky Factory Luminous Rectilinear SkyCeilings installed in the Radiotherapy suite, American British Cowdray Cancer Center in Mexico City, Mexico. (The Sky Factory, 2012)

Patient-centered Care

One of the primary goals of evidence-based design research is the creation of supportive healthcare environments focused on patient-centered care, which originated as part of The Planetree model for Healthcare Design in 1978 in an effort to redefine the healthcare experience by encouraging multi-dimensional healing emphasizing care from the patient's perspective. The dimensions of healing include psychological, physical,

emotional, spiritual, and social ones and rely on a holistic approach consisting of nine points:

1. Significance of human interaction
2. Partnership of family and friends in the healing process
3. Information and education as tools to empower patients
4. Architecture and design that supports health and healing
5. Spirituality and the importance of inner resources
6. Nutrition and nurturing qualities of food
7. Healing arts
8. Human touch
9. Complementary therapies not part of traditional care (Kopec, 2006, 212; Malkin, 2008, 88; McCullough, 2010).

In the same way as the term "evidence-based design" has become a catchphrase within the healthcare design industry, "patient-centered care" is also often used loosely without a clear or strong understanding of the definition. By designing services, workflow, and care from the patient's perspective, efficiency and quality of care provided can be increased while errors, costs, and stress decrease (Delvin and Arneill, 2003, 673-674). This approach has probably become most evident in large, single-occupancy residential type patient rooms with amenities for families offering support and with close proximity to staff now located at decentralized nurse stations.

Patient-centered care is a model that can be expanded upon through evidence-based design. The benefit of merging these concepts with others in evidence-based design is to strive to create a more holistic supportive healing environment. Evidence-based design is not about creating hospitals that are simply more pleasant; it is about creating an environment that is safer, encourages patient recovery, supports family participation, and is more efficient and supportive for staff. If the larger goal is to create environments that are caring, therapeutic, and restorative for patients, visitors, and staff

all coping with psychological and physiological stress, then the project most likely will "result in demonstrated improvements in the organization's clinical outcomes, economic performance, productivity, customer satisfaction, and cultural measures" (Smith, 2007b, 2; Smith, 2007c, 3; Ulrich and Zimring, 2004, 26).

Places of Respite

Based on the cited research, the built environment is an important factor in the healing process. However, the traditional approach to design of the modern built environment has encouraged the depletion and alteration of natural systems and furthered the separation between humans and the natural world. "This design paradigm has resulted in unsustainable energy and resource consumption, major biodiversity loss, widespread chemical pollution and contamination, extensive atmospheric degradation and climate change, and human alienation from nature" (Kellert, Heerwagen, and Mador, 2008, 5). Many of the sustainable movements have been generated in response to the massive task of reducing the environmental impact of the built environment in efforts to stop or reduce the issues stated previously. These programs include Leadership in Energy and Environmental Design (LEED), The Green Guide for Healthcare (GGHC), Living Building Challenge, and The Sustainable Sites Initiative (SITES). The most widely accepted building rating system in the United States is the U.S. Green Building Council's LEED program. The LEED 2009 version introduced more specialized rating systems, including one for healthcare, that deals with some of the specific issues faced with healthcare facilities energy consumption, filtration and HVAC systems, and medical equipment and furniture to name a few. Two of the new credits it also introduced are under LEED's "Sustainable Sites" category and are "Connection to the Natural World – Places of Respite" (SS Credit 9.1) and "Connection to the Natural World – Direct Exterior Access for Patients" (SS Credit 9.2).

The intent of the first credit concerning Places of Respite is to "provide [accessible] outdoor places of respite on the healthcare campus to connect patients, staff,

and visitors to the health benefits of the natural environment"(LEED 2009 for Healthcare, 2010). The settings for patients and visitors must be equal to 5 percent of the net usable program area of the building or project and additional dedicated outdoor space for staff must be equal to 2 percent of the net usable program area. In addition to the spatial requirements, both areas are required to:

1. Allow for complete accessibility
2. Be free from clinical care
3. Provide natural elements with access to fresh air, views to the sky, and seasonal changes
4. Provide options for shading with accessible seating areas below
5. Be free of environmental tobacco smoke

Additional program areas can factor into the overall percentages at various rates outlined in the LEED handbook. The types of programs included are:

1. Conditioned interior greenhouses, atria, and solaria
2. Special-use gardens utilized for horticulture therapy
3. Nature trails with universal access

The intent of the next credit, Direct Exterior Access for Patients, states that patients and staff must be provided "with the health benefits associated with direct access to the natural environment" (LEED 2009 for Healthcare, 2010). This credit requires direct access for inpatients and outpatients with a clinical length of stay longer than four hours to an exterior courtyard, terrace, garden, or balcony with a minimum area of five square feet per 75 percent of each patient group. Again, the space is required to be free of environmental tobacco smoke, and be at least 100 feet away from building exhaust, loading docks, parking lots, and other sources of air pollutants. (Additional details for

both of the requirements including calculations, exceptions, etc. can be found in the LEED 2009 for Healthcare handbook).

Similarly, Green Guide for Health Care (GGHC) released their Version 2.2 in 2007. This self-certifying system has a similar format to LEED and was a precursor in the Healthcare industry providing best practice guidelines for sustainable healthcare design, construction, and operations. There are many credits that are shared within this system and LEED 2009 for healthcare including a detailed credit discussing "Places of Respite" which they define as "a place on the health care campus to connect health care patients, visitors, and staff to health benefits of the natural environment" (Smith, 2007a, 1). These natural benefits are described in the form of positive distractions and natural cycles that "rejuvenate the senses and reduce stress levels for employees and patients alike, thus contributing to the important goals of reducing medical errors and improving patient health outcomes" (Smith, 2007a, 1).

Outdoor places of respite should consider environmental factors of the site as well as adjacency requirements of the interior. These adjacencies should consider spaces that can most benefit from nearby access to the exterior environment as well as the benefit of views of nature being brought in to the interior. Some of these interior spaces may include waiting rooms, public corridors, and clinical spaces which can all benefit from the ease of way-finding through natural elements. Some examples of outdoor places of respite are:

1. Meditative gardens
2. Healing gardens
3. Therapeutic and enabling gardens
4. Rooftop gardens and green roofs
5. Staff gardens (with seating)
6. Rehabilitation, restorative, and enabling gardens

Likewise, interior places of respite can be incorporated into the interior design by continuing materials and elements of nature throughout the facility. As the research has demonstrated, views to nature are important for restoration and GGHC requires that 90 percent of the collective area for indoor places of respite should have a direct view onto nature. Some examples of indoor places of respite are:

1. Interior greenhouse gardens and atria
2. Display areas of flora and fauna
3. Corridors that can accommodate seating with views of nature and seasonal changes
4. Family consultation spaces with views
5. Areas to pause (with seating) adjacent to destination points
6. Chapels, meditation spaces, and bereavement rooms
7. Patient and family libraries and resource areas (with seating)
8. Therapy and exercise areas

By integrating indoor and outdoor places of respite throughout a facility, the boundary between interior and exterior becomes ambiguous and more wholly brings nature into the healing process. This is not a process that happens haphazardly throughout schematic design and design development; these spaces should be identified and maintained throughout design and value engineering processes. If elimination is threatened due to budget concerns, consider recognizing areas for donor and naming opportunities. Some considerations to encourage the realization and effectiveness for places of respite are:

1. Prevailing winds and solar orientation
2. Orientation relative to exterior views of nearby and distant nature or other natural features that introduce day-light and seasonal changes
3. Choice, variety, and dimensional design

4. Way-finding and accessibility
5. Sensory engagement of all five senses as well as areas for specific sensory stimulation
6. Smaller spaces that are convenient throughout the facility as opposed to one larger space that may not be as accessible
7. Areas with consideration for immune suppression conditions and sunlight sensitivity (i.e., chemical and air quality concerns)
8. Accessible nature trails with seating
9. Screening of negative view, HVAC equipment, and vehicular traffic
10. Requirements for privacy and security
11. Requirements for maintenance (Smith, 2007a, 1-4)

Chapter 4: Biophilic Design for *Interior* Healthcare and Healing Environments

Ian McHarg is credited with forming the phrase "design with nature" derived from his 1969 book of the same title discussing site design and land use planning. This idea was very successfully received by the design community and has since become an integral principle in healthcare design (Smith, 2007b, 1). Hundreds of research documents from environmental and social researchers, environmental behavior psychologists, and design professionals have been published over the last 25 years demonstrating the methods and analysis of health outcomes related to human-nature connection. This growing body of knowledge has been funded by philanthropic groups like the Robert Wood Johnson Foundation and the Merck Family Fund in addition to sponsorship by nonprofit organizations such as The Center for Health Design (Smith, 2007b, 1). The resulting research has contributed to a shift in principles for environments of care demonstrating the importance of affordance of designing with nature for all users. The majority of the healing effects from designing with nature in the interiors are from the biophilic or sensory encounters stimulating or increasing one or more of the senses (seeing, hearing, smelling, tasting, and touch) which are integral to our perceptions, emotions, and psychological well-being (Kline, 2009, 161; Smith, 2007b, 9).

VALUES IN NATURE

At the heart of the theory of biophilia are the values, meanings, or benefits people attach to nature. As discussed previously, this is an inherent quality, but the extent of value is learned or greatly influenced by individuals' experiences and cultural support. There are nine methods related to how humans value nature that are influential in their physical, material, emotional, psychological, and spiritual well-being:

1. Aesthetic – physical allure of nature
2. Dominionistic – control of nature

3. Humanistic – emotional attachment to nature
4. Moralistic – Spiritual association to nature
5. Naturalistic – direct experiences with nature
6. Negativistic – fear of nature
7. Scientific – empirical observation and study of nature
8. Symbolic – metaphoric value of nature
9. Utilitarian – physical and material benefit of nature (Kellert, 2005, 34, 50)

These nine values reflect our interconnectedness with natural systems. In historic and contemporary time, humans consistently rely on natural processes and systems to obtain building material for shelter, food for survival, and medicine for health. We also depend on ecosystem services that produce water, plants, nutrients, and that are able to decompose wastes. Humans have an inherent desire to dominate and understand the natural world explaining the environment through classifications, categories, and labels. Through observation, understanding, and immersion in the natural world, humans derive physical and mental benefit as cognitive development and learning are nurtured fostering an increased sense of well-being. This relationship can foster a spiritual response as humans ponder the purpose and meaning of life and its unity to creation. Recognition of unity and order is perceived in the beauty of the natural world eliciting spiritual, metaphorical, emotional, and sensory understanding. These responses contribute to the value applied to natural systems and the creation of a sense of place within the natural world (Kellert, 2005, 51-57; Nisbet, Zelenski, and Murphy, 2009, 716-717; Wilson, 1984).

SENSORY AESTHETICS AND BIOPHILIA

> When sight came, the first moment of sight was the realization of beauty. I don't mean beautiful, or very beautiful, or extremely beautiful. Just simply beauty itself, which is stronger than any adjectives that you might find to add to it. It is total harmony without knowing, without reservation, without criticism, without choice. It is a feeling of total harmony as though you were meeting your maker,

> the maker being that of nature…You cannot design anything without nature helping you. Louis I. Kahn (quoted in Lobell, 1979)

How can building design suggest the beauty and qualities of nature in all of its relationships and forms without direct biomimicry? Nature abounds with variety in sensory rich patterns, textures, light, smells, sounds, and color. As we move through a natural environment, we are met not "just with visual delight, but also with sounds, haptic sensations from the feel of wood or stone, and variations in temperature and light as we move through a space" (Kellert, Heerwagen, and Mador, 2008, 229). The sensory expression of biophilia is crucial in the creation of building design that elicits positive responses, engagement with place, well-being, and values in nature. The aesthetics of nature in the built environment are communicated through the use of materials, colors, light, air, spatial structures, patterns, textures, movement, and openings that connect the interior to exterior. These qualities can be categorized into seven attributes which reinforce the interconnection of sensory aesthetics and biophilia:

1. Sensory richness
2. Motion
3. Serendipity
4. Variations on a theme
5. Resilience
6. Sense of freeness
7. Prospect (visual access) and refuge (enclosure) (Kellert, Heerwagen, and Mador, 2008, 229, 234)

To better understand these attributes, imagine taking a walk in the woods. You immediately are greeted with the rich sensory elements that abound: the smell of damp, decaying foliage on the forest floor; the sound of rustling leaves overhead as the wind, birds, and wildlife move through the branches; delicate ferns, intricate lichens, and wildflowers in endless patterns, texture, and vivid colors growing on rocks, trees, and

springing up from the ground; the reminder from your childhood of the tart taste of mulberries, as you side-step the fallen dark-purple berries that litter the packed-earth path. Following this path deeper into the woods, you feel as if you are entering a tunnel through the lofty trees that act as columns to support the boundless space surrounding you. The notion of where the woods start or end becomes ambiguous as you progress deeper into the cavernous space. As you continue to survey the natural environment, you are reminded that nature is in constant motion – that it relies on cyclical patterns that fluctuate with the day, season, or weather. Water moves through streams at varying power throughout the year; light arches in through the canopy at different levels and intensity as the trees bud in the spring, leaf out and shade in the summer, and seem to capture the fiery colors of the sun in the fall dropping to the ground exposing their naked branches in the winter. This ebb and flow of the rhythms of nature are pleasing and soothing to the passive human observer. We discover amazing, coral reef-like detail as lichens are examined closely further revealing the neon-like gradient colors that hug the grain of rough bark on a fallen tree. We notice ants marching through the valleys of this bark and consider their encounter with the lichens thinking it probably is more akin to our relationship to the surrounding forest trees. Recognition of this pattern of various scales reminds us of the rhythm and balance in nature as well as the interconnectedness and resilience of natural systems, plants, and animals. Discovering and contemplating all of this provides an overwhelming sense of beauty, freedom, and peace as we focus on the waxing and waning life around us. These rich biophilic sensations are profuse in the outdoor environment and it seems only logical that through a biophilic design approach for the built environment people and nature can again begin to foster sensory rich and beneficial contact.

BIOPHILIC DESIGN ELEMENTS AND ATTRIBUTES

Nature exhibits biophilic qualities at varying scales, pattern, and form. Regardless of the feature, they still remain interconnected; the same should apply to the human built environment. There are two basic dimensions of biophilic design: organic or

naturalistic and place-based or vernacular (Kellert, Heerwagen, and Mador, 2008, 5-6). The first, organic or naturalistic dimension is defined as "shapes and forms in the built environment that directly, indirectly, or symbolically, reflect the inherent human affinity for nature" (Kellert, et. al., 2008, 5). Examples of elements that directly affect this attraction are self-sustaining natural features such as plants, animals, daylight, habitats, and ecosystems that are more unconsciously or freely interacted with. Our indirect experiences include involvement with nature that require human assistance for survival such as aquariums, water fountains, and potted plants. The last category of experience, symbolic or vicarious, refers to the representation of the natural world through picture, image, video, metaphor, etc. and does not actually require contact with real nature (Kellert, et. al., 2008, 5-6). The second dimension, place-based or vernacular, is defined as "buildings and landscapes that connect to the culture and ecology of a locality or geographic area" (Kellert, et. al., 2008, 6). One of the central concepts of this dimension is the notion of "sense of place" which refers to the identity and meaning that individuals begin to project onto the built environment or the landscape and how these metaphors begin to affect personal or collective identities.

The two basic dimensions of biophilic design can be related to six biophilic design elements that can then be expanded into more than 70 biophilic design attributes. The elements and attributes, represented in Appendix D, are derived from the research of Stephen Kellert who is a professor of Social Ecology at the Yale School of Forestry and Environmental Studies (Kellert, et. al., 2008).

BIOPHILIC DESIGN FOR INTERIOR HEALTHCARE ENVIRONMENTS

Chapter five will explore more specific hypotheses of how the theoretical approaches represented in Appendices Table 3.1-3.6 can begin to be synthesized with the research related to environmental psychology, healing landscape, and evidence-based design to inform *interior* design solutions for healthcare environments. However, it is important to first summarize what basic characteristics contribute to a healing

environment, which are the same whether the environment being designed is interior or exterior. These components include:

1. Air quality
2. Thermal comfort
3. Noise control
4. Privacy
5. Light
6. Views of natures
7. Access to nature
8. Positive distractions
9. Visual serenity (for ill patients)
10. Visual stimulation (for patients that are recuperating)
11. Choices and options
12. Social support
13. Control (McCullough, 2010, 47)

Healing has previously been defined as a process that promotes overall well-being by providing relief of physical symptoms, facilitating stress reduction, increasing comfort, and supporting improvement in the overall sense of well-being (Marcus and Barnes, 1999, 3). Today's healthcare environments need to be one that addresses the reduction of stress, make provisions for healing characteristics (as outlined above), and physically and psychologically support patients, visitors, and staff. To further facilitate well-being, these spaces need to be environments that reconnect the body and mind and foster a sense of place (Burnett, 2003, 21). These healing effects can be achieved through biophilic and sensory encounters within the facility. Environmental behavior theories show the predictable patterns that humans exhibit in biophilic responses to the natural environment, theoretically making responses more predictable in a built environment by incorporating biophilic elements and attributes.

Chapter 5: Proposed Design Guidelines and Considerations for Biophilic Interior Design in Healthcare Environments

Although these design guidelines primarily deal with the interior environment, in order for many of them to be implemented successfully they require the support and collaboration of an interdisciplinary team. The interior and exterior spaces should complement each other due to the proposed or required adjacencies. A little over a year into my career as a healthcare interior designer, I recalled the client asking me many questions during design development about landscape amenities such as fountains, benches, planters, etc. Having not seen the landscape drawing – or even met the designers responsible for this portion of the project – I joked that since it was "exterior" it was certainly out of my "interior" realm. Thankfully, my client understood the importance of a cohesive design aesthetic and pattern from the overall site down to the smallest interior detail, but unfortunately so many clients and users do not. It is then the responsibility of the entire project team to ensure a cohesive project focused on these adjacencies and relationships meaning landscape architects and interior designers need to be integrated into an interdisciplinary team during the programing phases of the project. This will provide the opportunity to take the concept of biophilic design for interiors to new levels that create spaces that are more restorative of physical and psychological well-being.

RESEARCH BASED DESIGN HYPOTHESES

"Translating the abstract into physical design terms requires the use of problem-solving or design methods that bridge the gap between the linear scientific path of thinking and the intuitive or artistic line of thought" (Tyson, 1998, 57). This section will propose design hypotheses based on the research presented from environmental psychology, healing landscapes, and evidence-based healthcare design. Each consideration is examined for its support of biophilic value and sensory aesthetic in hopes of being able to predict behavioral outcomes, healing characteristics, and to support well-

being for patients, visitors, and staff. The guidelines and hypotheses are meant to be a design framework that allows for creativity and innovation for interdisciplinary project teams.

INDOOR AND OUTDOOR CONNECTION

1. Extend Gardens into Lobbies and Waiting Areas

Description: Continue patterns, textures, materials, spatial arrangements, and forms from the exterior into the interior to increase connection to nature in spaces that are used by patients, visitors, and occasionally staff.

Design Considerations:

- Delineate or bound spaces with features that relate to the exterior
- Create subspaces within the larger gathering space
- Vary ceiling heights – provide areas that are open and filled with day-light and others that have lower ceiling heights becoming more private
- Continue paving patterns and materials into the lobby or waiting areas

Figure 3: Franklin Woods Community Hospital, Johnson City, TN, Karlsberger

Figure 4: Franklin Woods Community Hospital, Johnson City, TN, Karlsberger

Figure 5: UCSD Sulpizio Family CVC, San Diego, CA, RTKL Associates, Inc.

Figure 6: UCSD Sulpizio Family CVC, San Diego, CA, RTKL Associates, Inc.

2. Provide Terraces or Solariums Adjacent to Patient Rooms*

Description: Terraces or solariums can provide additional, more accessible or private access to nature for patient's, visitors, and staff. It can bring additional day-light and, in the case of a terrace, will provide natural ventilation.

*The provision of natural ventilation may not be appropriate in all locations depending on site, urban development and pollution, or patient acuity.

Design Considerations:

- Provide terraces in mild climates
- Provide a solarium in more extreme climates
- Site terraces and solariums for optimal passive heating and cooling of patient rooms
- Specify furniture and native plant material
- Specify proper shading devices for sun control on the exterior and on the interior to ensure privacy
- Ensure ADA accessibility for wheelchair and IV stand access by providing a flush threshold and proper clearances

Figure 7 & 8: Green Patient Lab 3.0, Concept and Mock Room, Anshen + Allen

Figure 9: Lucile Packard Children's Hospital, Stanford University, Palo Alto, CA, Perkins + Will

3. Provide Terraces or Solariums Adjacent to Family Lounges or Waiting Areas

Description: Terraces or solariums can provide additional, more accessible access to nature for visitors. It can bring additional day-light and, in the case of a terrace, will provide natural ventilation.

Design Considerations:

- Provide terraces in mild climates
- Provide a solarium in more extreme climates
- Site terraces and solariums for optimal passive heating and cooling of patient rooms
- Specify furniture and native plant material
- Specify proper shading devices for sun control on the exterior and on the interior to ensure privacy
- Ensure exterior spaces are free from environmental tobacco smoke (ETS)
- Ensure ADA accessibility for wheelchair access by providing a flush threshold and proper clearances

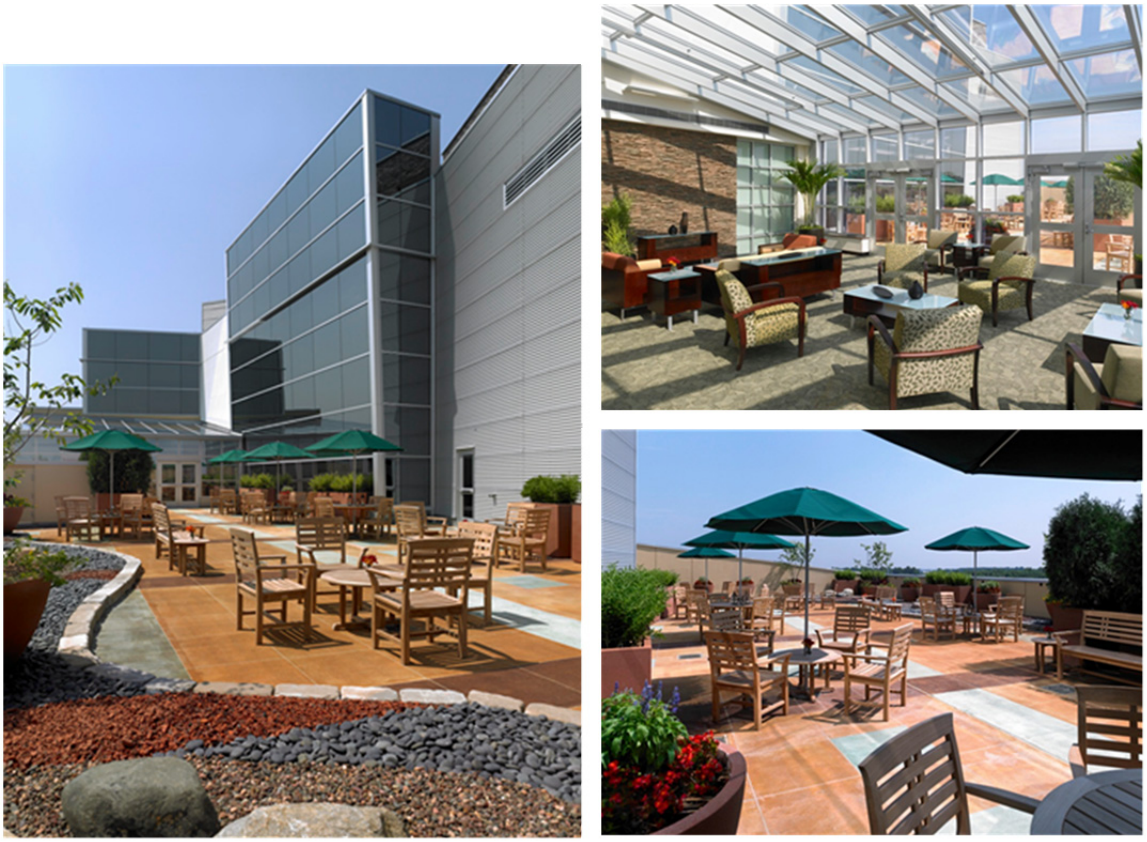

Figure 10, 11, & 12: Community Hospital North, Indianapolis, IN, RTKL Associates, Inc.

4. Provide Private Staff Outdoor Space Adjacent or Close to Break Rooms or Lounges

Description: Terraces or solariums can provide additional, private access to nature for staff that is free from clinical care. It can bring additional day-light and, in the case of a terrace, will provide natural ventilation.

Design Considerations:

- Provide terraces in mild climates
- Provide a solarium in more extreme climates
- Site terraces and solariums for optimal passive heating and cooling of patient rooms
- Specify furniture and native plant material
- Specify proper shading devices for sun control on the exterior and on the interior to ensure privacy
- Ensure exterior spaces are free from environmental tobacco smoke (ETS)

Figure 13: Seattle Children's Bellevue Clinic, Seattle, WA, NBBJ

5. Provide Physical Access to Nature from Dining Areas

Description: Dining areas are spaces that are used primarily by visitors and staff. Opportunities to for outdoor eating can increase access to nature and creates a connection between the interior and exterior environment

Design Considerations:

- Create an accessible, defined area for outdoor eating
- Provide seating options with various levels of shade and sun
- Consider introducing plant material such as herbs into perimeter plantings or an innovative interior wall feature
- Take advantage of the non-clinical setting and consider introducing water features in the exterior environment
- Ensure ADA accessibility for wheelchair access by providing a flush threshold and proper clearances

Figure 14: Advanced Treatment and Development Center, Seoul, Korea, HDR, Inc.

Figure 15: Brochstein Pavilion at Rice University, Houston, TX, The Office of James Burnett

Figure 16 & 17: Vapiano Restaurants, Munich and various international locations

6. Locate Meditation Gardens or Atriums Adjacent to Chapel

Description: Because of the spiritual or restorative effects of nature and landscape, include smaller meditation gardens off of chapels.

Design Considerations:

- Create a space that is protected and private
- Include design features that allow for sitting among plant material or flowers
- Provide visual privacy from the interior to exterior and vice versa
- Consider signage or design features that encourage quietness or contemplation
- Ensure ADA accessibility for wheelchair access by providing a flush threshold and proper clearances at the garden entry and at all paths
- Include alcoves for wheelchairs with fixed seating that are enveloped by plantings

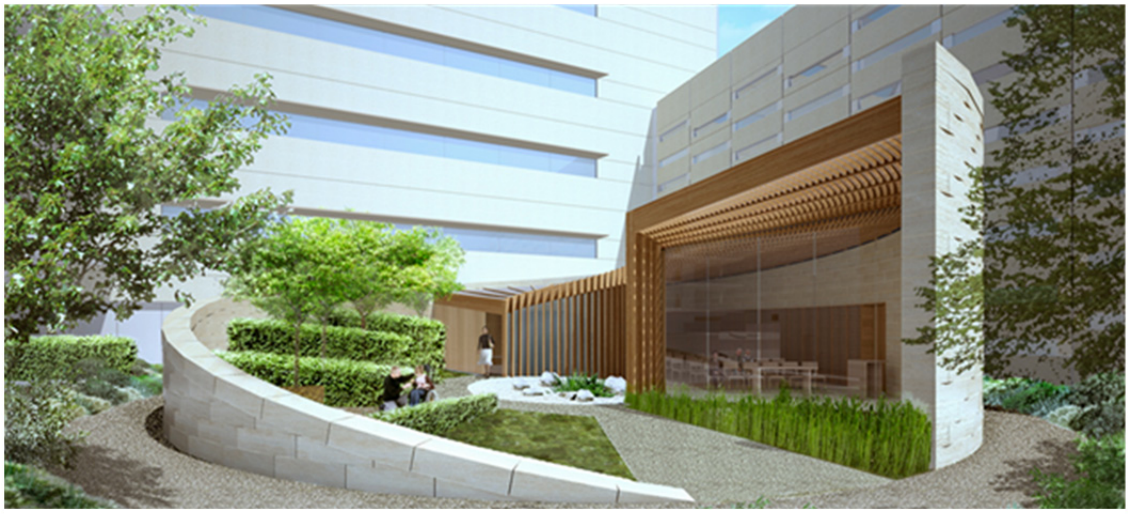

Figure 18: Lucile Packard Children's Hospital, Stanford University, Palo Alto, CA, Perkins + Will

Figure 19: Community Hospital North, Indianapolis, IN, RTKL Associates, Inc.

Figure 20: Sentara Williamsburg Regional Medical Center, Williamsburg, VA, HDR, Inc.

7. Place Window Seats and Alcoves Along Public or Long Corridors

Description: Provide space to stop and pause to view nature. By providing alcoves, the linear circulation space becomes a place that connects patients, visitors, and staff to nature.

Design Considerations:

- Locate convenient, smaller spaces throughout the facility
- Very ceiling heights and seating options within these spaces
- Introduce materials and plants that relate to the exterior
- Provide alcoves large and deep enough to accommodate wheelchairs and the required ADA clearances

Figure 21 & 22: Bellevue Medical Center, Bellevue, NE, HDR, Inc.

8. Provide Nighttime Lighting of Gardens for Views from Interior

Description: Healthcare environments are active twenty-four hours a day. Consider providing landscape lighting of exterior features to allow the spaces to still serve as a positive distraction at night

Design Considerations:

- Highlight a focal point or larger trees within the space
- Consider lighting any water features
- Provide perimeter path lighting for spaces that are accessible twenty-four hours a day

Figure 23: Essex Psychiatric Hospital, Cedar Grove, NJ, Mahan Rykiel Associates

Figure 24: The Heart Hospital Baylor Plano, Plano, TX, RTKL Associates, Inc.

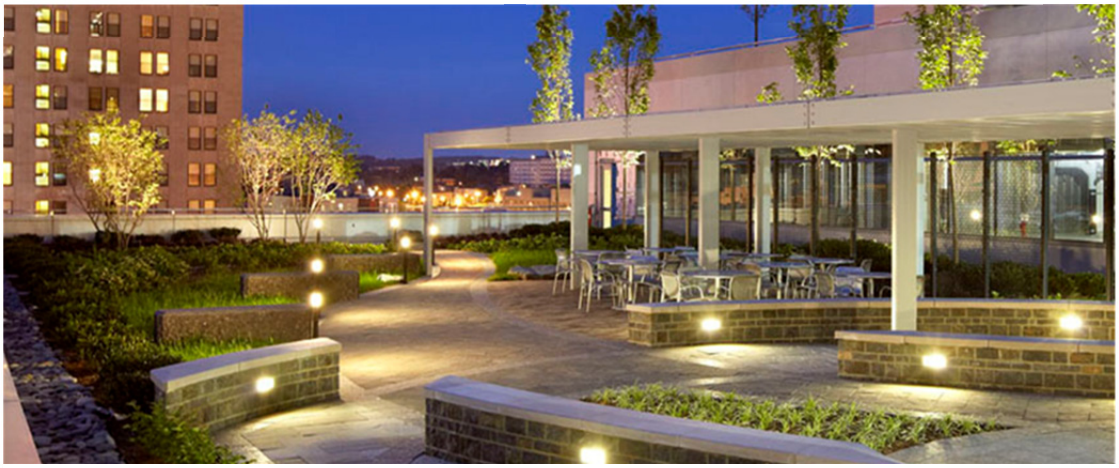

Figure 25: Mercy Medical Center, Baltimore, MD, Mahan Rykiel Associates

9. Incorporate In-between Areas from Interior to Exterior

Description: Transitions between the interior and exterior create a sense of security as you move from one environment to the next. It also allows for exterior spaces that provide physical protection from direct sun and other extreme weather.

Design Considerations:

- Provide portals or thresholds that blur the line of interior and exterior
- Ensure portals, thresholds, and paths are ADA compliant and wheelchair accessible
- Consider fenestrations that allow for dappled sun and breezes to move through the in-between space

Figure 26: Seattle Children's Bellevue Clinic, Seattle, WA, NBBJ

10. Views to the Exterior

Description: Due to the healing quality of views to nature and the positive distraction natural environments provide, it is vital to consider views from the interior to the exterior from spaces occupied by patients, staff, and visitors.

Design Considerations:

- Consider the proportions of these views in relation to human scale
- Provide views that are in proximity to natural ecosystems around the site
- Provide a view from every patient bed
- Consider inboard toilet locations (as opposed to outboard) to maximize window size
- Provide views from all treatment spaces
- Provide views from bereavement and consult rooms
- Provide views from not just public corridors, but also from staff corridors
- Provide views from family and staff lounges
- Provide views from elevator lobbies
- Provide views from nurse stations or charting stations
- Where able, create vertical openings so the viewer can take in the earth, vegetation, and sky
- Provide operable windows where applicable

Figure 27: Bellevue Medical Center, Bellevue, NE, HDR, Inc.

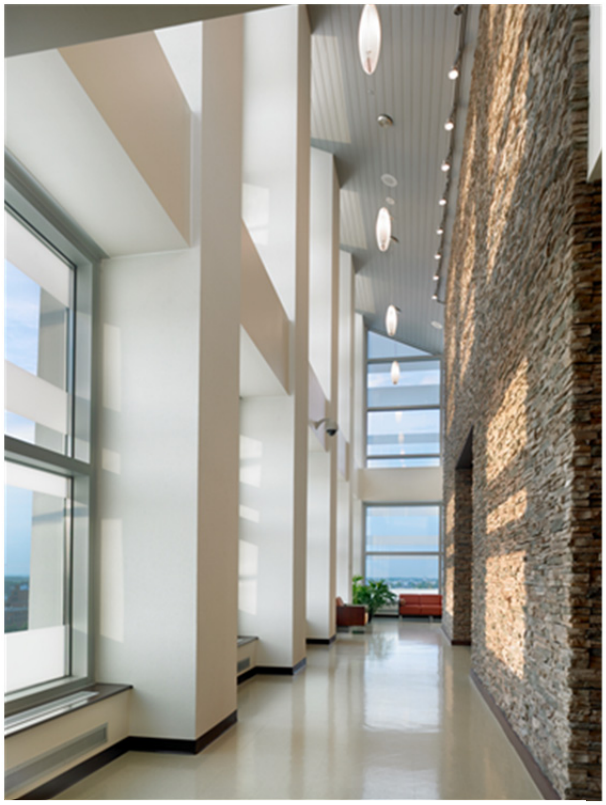

Figure 28: Community Hospital North, Indianapolis, IN, RTKL Associates, Inc.

Figure 29: Baylor McKinney, McKinney, TX, RTKL Associates, Inc.

Figure 30: Community Hospital South, Indianapolis, IN, RTKL Associates, Inc.

Figure 31: Central DuPage Cancer Center, Warrenville, IL, RTKL Associates, Inc.

Figure 32: The Heart Hospital Baylor Plano, Plano, TX, RTKL Associates, Inc.

11. Situate Courtyards so They Can Serve as Way-finding Elements

Description: Natural features can serve as easy way-finding elements. Situate circulation (vertical and horizontal) adjacent to courtyards for ease of way-finding and to allow for natural light to penetrate the interior environment.

Design Considerations:

- Provide access into the courtyard and terraces or windows from levels above
- Design a focal point of the courtyard to serve as an item that is recognizable whether in the space or moving around it
- Consider the walls as part of the courtyard design
- Provide proper screening or sun control where needed

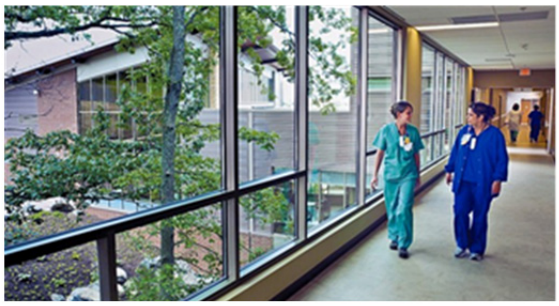

Figure 33 & 34: Franklin Woods Community Hospital, Johnson City, TN, Karlsberger

Figure 35: Dell Children's Medical Center of Central Texas, Austin, TX, Karlsberger

12. Provide Smaller Atrium Gardens

Description: Atriums allow natural light and plant material to be included in spaces that are not on the perimeter of buildings. They can also serve as way-finding elements and provide access to natural elements.

Design Considerations:

- Provide access into the atrium and terraces or windows from levels above
- Use atriums to link adjacent spaces
- Consider placing atriums next to internal waiting rooms to serve as positive distractions
- Consider privacy needs of adjacent rooms
- Ensure ADA accessibility for wheelchair access by providing a flush threshold and proper clearances at the atrium entry

Figure 36 & 37: Community Hospital North, Indianapolis, IN, RTKL Associates, Inc.

13. Provide Indoor Nature Walking Path

Description: Consider the public interior circulation as a nature path including views to nature, regional nature photography, design features, and materials. This can serve as a positive distraction for family and staff especially in climates with extreme weather.

Design Considerations:

- Provide handrails, goals, and resting points throughout the designated path
- Consider the path as an opportunity for physical exercise and movement
- Provide visitors and patients maps of outdoor spaces and indoor natural features, materials, and art
- Consider an educational program centered around these features led by volunteers

Figure 38: Community Hospital North, Indianapolis, IN, RTKL Associates, Inc.

14. Provide Access to Sensory Features and Materials

Description: Provide sensory experiences for patients, visitors, and staff at all scales throughout the hospital. These are opportunities that stimulate curiosity, imagination, exploration, and discovery.

Design Considerations:

- Consider introducing sounds of nature or water in interior spaces that are adjacent to exterior spaces containing these features
- Introduce fireplaces into waiting areas or lounge. These create a sense of warmth and a residential quality that is soothing
- Consider plantings and materials that have tactile qualities
- Select some plants whose foliage moves easily
- Consider introducing sensory artwork that simulates natural sounds, forms, or processes into public spaces (ex: Bertoia's *Sonambient* sculptures and Ned Kahn's Pebble Chime)

Figure 39: Children's Medical Center Tower IIIB, Dallas, TX, FKP Architects/RTKL Associates, Inc.

Figure 40: Baylor McKinney, McKinney, TX, RTKL Associates, Inc.

Figure 41: Arzanah Medical Complex, Abu Dhabi, United Arab Emirates, HDR, Inc.

15. Incorporation of Day-light in Unexpected Locations

Description: Design to introduce day-light deep in the interior or to fill a space in unexpected ways.

Design Considerations:

- Consider the contrast and balance of natural and artificial light
- Introduce the full color spectrum of natural light
- Reflect light into interior spaces to avoid glare
- Introduce pools of light to encourage movement into a space
- Consider clerestories in patient bathrooms to introduce day-light but retain privacy

Figure 42: Sentara Williamsburg Regional Medical Center, Williamsburg, VA, HDR, Inc.

Figure 43: Community Hospital North, Indianapolis, IN, RTKL Associates, Inc.

Figure 44: Methodist Mansfield Medical Center, Mansfield, TX, RTKL Associates, Inc.

Figure 45: Bathroom concept, Main Line Lankenau Medical Center, RTKL Associates, Inc.

16. Use of Screens to Filter Light and Views

Description: Incorporate screens to filter views and manipulate the shape and form of natural light

Design Considerations:

- Include colonnades, porches and foyers with trellised perimeters
- Screen negative views such as HVAC equipment and traffic
- Introduce screens or curtains to increase level of privacy (or perceived privacy)

Figure 46 & 47: National Heart Centre, Singapore, Broadway Malyan and Ong & Ong Architects

Figure 48 & 49: Cha Hospital, Seoul, Korea, KMD Architects

INTERIOR PLANTS

17. Introduce Plant Material into the Interior

Description: Provide interior plantscapes to increase access to nature, serve as positive distractions, and offer benefits of biofiltration

Design Considerations:

- Design built-in features for plants to insure their incorporation into projects
- Vary heights of features so that some are at eye-level for people in wheelchairs
- Consider historically significant plants of the region or site
- Introduce native plant species where applicable
- Incorporate shelves into the footwall to allow for patients to view plants from the bed (as opposed to the alternative of the bedside cabinet)
- Consider plants for their contrast or harmony in texture, form color, and arrangement within the interior environment

Figure 50: Memorial Sloan-Kettering Cancer Center, Brooklyn Infusion Center, Brooklyn, NY, ZGF Architects

18. Forms – Simulate Rather than Replicate Natural Elements

Description: Simulate natural forms through shapes, patterns, texture, details, and processes of nature as opposed to mimicking them

Design Considerations:

- Consider plant, foliage, shell, spiral, or egg-like forms
- Reference geological systems and vernacular forms within the local or regional context
- Think of columns like trees within the space
- Introduce sinuous, flowing shapes
- Provide orderly variation on a basic pattern
- Consider golden proportions and hierarchy

Figure 51: Central DuPage Cancer Center, Warrenville, IL, RTKL Associates, Inc.

Figure 52: Katz Women's Hospital and Zuckerberg Pavilion, New Hyde Park, NY, SOM

19. Materials

Description: Incorporate natural materials or finished which emulate natural materials within the interior environment

Design Considerations:

- Incorporate natural colors as appropriate keeping in mind that some colors can interfere with the nurses' assessments of patients' skin tones, agitate patients, visitors, and staff, and disorient certain patient populations
- Reference local and indigenous materials whenever possible to increase the sense of place
- Include materials that have an expression of age such as patina metals, salvaged wood, honed stone, etc.
- Use material color and texture to assist in way-finding

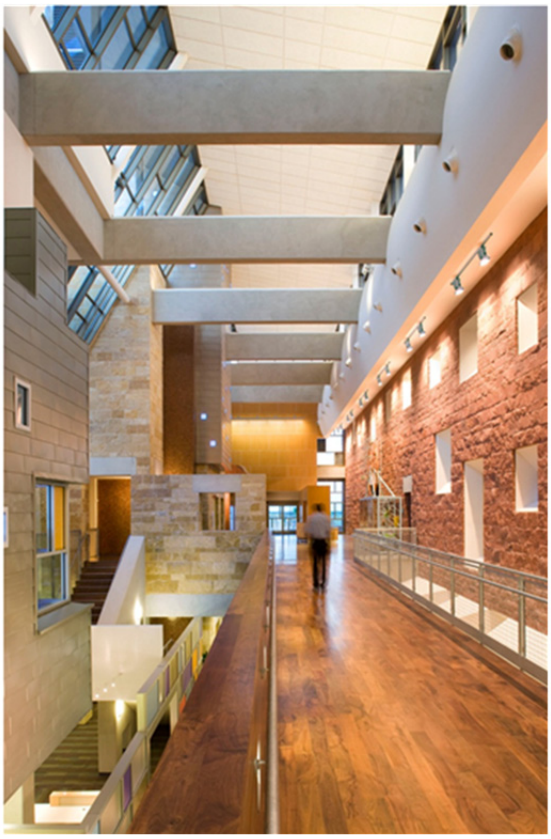

Figure 53: Dell Children's Medical Center of Central Texas, Austin, TX, Karlsberger

Figure 54: Bellevue Medical Center, Bellevue, NE, HDR, Inc.

20. Seating

Description: Provide different seating arrangements and different experiences while seated.

Design Considerations:

- Provide pre-arranged seating and areas with reconfigurable seating
- Place seating in different areas of sun and shade within the interior
- Create a sense of enclosure and privacy within the seating groups
- Accommodate for social support by varying the size of seating within groups
- Provide seating areas next to wheelchair alcoves to allow for assisted transfer for persons in wheelchairs
- Vary the ceiling height above different ceiling groups to create spaces that feel more open or more private

Figure 55: The Methodist Hospital Outpatient Center, Houston, TX, WHR Architects

Figure 56: Central DuPage Cancer Center, Warrenville, IL, RTKL Associates, Inc.

Figure 57: University Health System, Design Competition, San Antonio, TX, RTKL Associates, Inc.

21. Way-finding

Description: Incorporate natural themes into way-finding systems

Design Considerations:

- Introduce regional elements of nature into signage
- Include culturally significant and nature themed colors into way-finding system

Figure 58 & 59: UCSD Sulpizio Family CVC, San Diego, CA, RTKL Associates, Inc.

Chapter 6: Conclusions

SUMMARY OF CONTRIBUTIONS

This thesis is meant to be viewed as a contribution towards developing evidence-based biophilic *interior* design solutions for healthcare environments. The interdisciplinary research and proposed guidelines are hypotheses for how to further design with nature for human well-being. They offer support and design considerations for psychological responses to nature within the *interior* healthcare environment. Several of these approaches have been implemented at various scales as illustrated in the previous section, but in order to contribute to the evidence that defines the healthcare interior design profession, the designs must be empirically tested to demonstrate, confirm, or deny its validity.

IMPLICATIONS FOR FUTURE RESEARCH

Due to the interdisciplinary nature of biophilic interior healthcare design, one major implication for future research can be stressed here, which derives from that interdisciplinarity. This implication would revolve around how to further integrate two biophilic elements--plants and air--which are recognized as having a significant impact on building occupants across all sectors of commercial buildings. For example, poor indoor air quality or lack of access to nature or positive distractions can become sources of environmental stress affecting recovery time and staff productivity (Malkin, 2001). Therefore, these features are extremely important to look at in the context of an interior health environment as they can address many of the physical and psychological responses to well-being for patients, visitors, and staff.

Plant Material and Biofiltration

(Note: plant material is not being proposed for every type of healthcare environment or all patient groups. Beyond some of the immune-sensitivities and infection control concerns that naturally arise from introducing plants, soil, flowers, water, etc. into a

complex environment, the theory and research in favor of plants as air purifies can be a basis for innovation solutions capable of addressing these concerns).

Reports show that humans spend around eighty percent of their time indoors where exposure to pollutants, chemicals, and microorganism in the air can result in poor indoor air quality (IAQ) leading to discomfort and serious health risks such as sick building syndrome, asthma, and multiple chemical sensitivities. Symptoms associated with poor IAQ such as headache, fatigue, shortness of breath, and dryness or irritation to the skin, eyes and throat are often reported by patients and staff in healthcare environments (Park, 2006, 25-26; Wood and Burchett, 1994, 363- 365). As a result, increasing attention is being directed towards building interiors as being influential in human health and well-being. In healthcare environments where infection control is a priority and with patients in an immunocompromised state, IAQ needs to be addressed at all possible levels. One *complementary* approach to increasing IAQ can be through the introduction of plant material into the interior environment.

Plants are often included in interior environments for their aesthetic value or to provide access to elements from nature, but they have also been shown to enhance satisfaction, performance, comfort, and well-being. One of the biophilic benefits of indoor plants is the haptic experience that exceeds simply looking at a picture of nature or viewing them from a window. "Plants provide various tactile experiences with distinctive or unique foliage, stem, flowers and fruit. By touching plants, individuals can be sensitive to the difference in texture between varieties, and the differences between young leaves and mature ones" (Park, 2006, 20). Olfactory and taste sensation also can be generated by introducing scented plants, herbs, and flowers within a space. Apart from their aesthetic value, there is now a growing amount of studies supporting the use of plants as natural filters in indoor environments (Fjeld and Bonnevie, 2002; Park, 2006; Raza, Shylaja, Murthy, and O. Bhagyalakshmi, 1991; Shareef, 1992; Wood, 2004; Wood et. al., 1994; Wood, Burchett, Orwell, and Torpy, 2003). Many of the original studies

demonstrating how typical house plants interact with and eradicate toxins in the environment were conducted by Dr. Bill Wolverton with the National Aeronautics and Space Administration (NASA) in the mid-1970s. The toxins that Dr. Wolverton and his colleagues specifically studied are commonly used chemicals, hazardous to human health, and are known carcinogens: benzene, trichloroethylene (TCE), and formaldehyde. A sealed experiment container was created; full plant foliage placed inside, and testing of the air began after a 24 hour period. Certain common plants were found to be more effective at removing benzene and TCE from the environment, while others were found to have removed a minimum of fifty percent of the formaldehyde (Park, 2006, 26; Shareef, 1992, 111; Wood, et al., 1994, 366).

More recent studies have also looked at the potting medium's contribution to the removal of toxins and VOCs in indoor air. Three different species of common household plants were again tested for their biofiltration rates in continuously lit indoor environments such as hotels and offices. Test results showed that after just 4-5 days there were remarkably lower levels of benzene and other VOCs in the air and that the levels were not only maintained, but improved with time. The same species of plants were then tested in a continuously dark chamber where photosynthesis stops and metabolic activity slows under conditions lacking light. Surprisingly the test provided almost exact results as the first, and even higher levels of VOCs were introduced to see if the absorption process would slow, which it did not (Fjeld and Bonnevie, 2002, 6; Wood, et al, 2003, 5-6). As a result of the similar results, several additional studies were conducted. The first was to remove the plant, replace the pot with potting mix, and place it back into the chamber. The same VOC levels were introduced and results were similar, but typically less than the prior test with the plant. Next, the reverse of the test was conducted and plants whose roots had been thoroughly rinsed in sterile water to remove any potting medium were placed in hydroponic solutions and again produced similar results. Finally, pots with soil that had not been previously planted were tested and demonstrated slow levels of decreasing absorption. These results confirmed that the common

microorganisms in potting soil mediums are not sustained or will not last long without the presence of a growing plant. The study concluded that the continued process "is a true biological response, and not merely an adsorption/absorption process"…that "the differences in response among the plant species in [the hydroponic and soil mediums] suggest different relationships between the plant and the microorganisms associated with the root systems…this is a general plant-soil phenomenon," and finally that "it is well established from research with crop species that different plant species develop a species-specific soil flora around their roots, producing a symbiotic microcosm of activity" (Wood, et al, 2003, 5-8). A list of approved plants for biofiltration of indoor air is provided by the organization Green Plants for Green Buildings and can be found in Appendix E.

A primary concern for healthcare facilities when dealing with infection control is dust accumulation and airborne particulate transmission especially as the level of acuity increases. Lohrs and Pearson-Mims (1996) have conducted studies that demonstrate that the addition of potted plants around the perimeter of a room decreased dust accumulation on horizontal surfaces in the space as much as twenty percent compared to the room without plants (Fjeld and Bonnevie, 2002, 6; Park, 2006, 26-27). It is thought that as plant transpire water, the relative humidity of a space will rise (an average of about five percent in the Lohrs and Pearson-Mims study) causing more of the dust to bind as the leaf surface of the plant promotes sedimentation of the dust from the air (Fjeld et. al., 2002, 8; Lohrs and Pearson-Mims, 1996).

In spite of this research that continues to emerge, some healthcare facilities have been reluctant or unwilling to allow fresh or potted plants in patient areas due to the risk of infection arising from the medium in the container or the water in flower vases (Park, 2006, 27). However, according the Centers for Disease Control and Prevention, "flowers and potted plants need not be restricted from areas for immunocompetent patients," but "do not allow fresh or dried flowers, or potted plants, in patient-care areas for

immunosuppressed patients" (Sehulster and Chinn, 2003). Minimal to no evidence connects potted plant or cut flowers to hospital acquired infections in immunocompetent patient groups. Further studies demonstrate that the microorganisms found in water or potting mediums were not the same ones responsible for hospital acquired infection (Park, 2006, 27-28).

Although additional research needs to be conducted on indoor plant material and patient, visitor, and staff physical and psychological responses, it is apparent that there are healing and biophilic benefits of introducing plant material into this environment. As demonstrated, the introduction of plants into a healthcare setting can provide healing benefits by improving the air quality, allowing access to nature, serving as positive distractions, and sustain visual serenity. The potential for healthcare interior designers to collaborate with landscape architects, industrial designers, and engineers on innovative solutions that provide increased indoor air quality through biofiltration may ultimately lead to healing environments with higher levels of sensory aesthetics and biophilic value. "The human body is also able to detect changes in the indoor air quality far below the guideline concentrations...This means that even small changes in chemical impurities of the air, may influence health and discomfort symptoms" (Fjeld et. al, 2002, 8).

CONCLUSIONS

At the heart of this thesis research lies the theory of biophilia which describes the innate affinity that humans have for nature and suggests a scientific hypothesis for environmental behavioral responses within the creative fields of architecture and design. The exploration of the human-environment relationship is gaining recognition in diverse disciplines that support the beneficial psychological and physiological responses of connection to nature and human health and well-being. Natural environments afford healing and restorative benefits in the form of positive shifts in cognitive, physical, and social functioning. Although individual experiences with and exposure to nature differ, the majority of people believe in the healing value of nature and have similar preferences

for natural settings and the density or type of plants within them. In addition to these preferences, stress relieving benefits of natural environments are also widely recognized for their ability to provide a sense of control or privacy, a means for social support and interaction, opportunities for physical exercise and movement, and positive distractions through connection to nature. These preferences and behavioral responses have been recognized by landscape architects as they seek to design gardens with the ability to support the user and the healing processes.

By creating verdant environments that are sensory-rich and accommodate physical experiences with nature beyond the passive experience of simply viewing it from the interior, a garden can provide healing benefits beyond the architectural walls of the healthcare building. Through the introduction of guidelines and considerations, the field of healing landscape architecture has been able to design for positive environmental responses to create successful exterior healing environments. However, the same supportive characteristics, preferences, and stress relieving benefits of a natural healing environment need to be considered for the interior healthcare environment.

To further facilitate well-being, the built spaces need to be environments that reconnect the body and mind and foster a sense of place. These healing effects can be achieved through biophilic and sensory encounters within the facility. By focusing more on the human-environmental response research from environmental psychology, the methods for healing landscape architecture, and expanding on the principle of connection to nature in evidence-based healthcare design, healing interior environments can begin to be redefined. Using concepts of biophilic design to guide decisions for the built environment, spaces are designed to support healing through biophilic responses and connection to natural elements and systems. Through continued research, innovation, and interdisciplinary approaches, new solutions for increased integration of natural elements within the built environment can begin to foster greater levels of connection to nature and improved human health and well-being.

Appendices

APPENDIX A: TYPES OF OUTDOOR SPACE AT HEALTHCARE FACILITIES

TYPES OF OUTDOOR SPACES AT HEALTHCARE FACILITIES				
Outdoor Space:	**Description:**	**Advantages:**	**Disadvantages**	**Reference**
1. Landscaped Grounds	open space consisting of extensive landscaped areas between building ("park" or "campus")	1. Can tie together a variety of buildings into a campus like setting 2. Can provide a variety of landscapes from manicured lawns and flower beds to natural woodland or meadows 3. Can serve a variety of users and activities	1. Maintenance may be costly 2. Often piecemeal in development, the relationship between spaces, as well as interior-exterior connections, may be lacking in cohesiveness.	pg 116
2. Landscaped Setback	an area in front of the main entrance to a medical center, usually comprising lawns and trees, and often required by zoning regulations.	1. May evoke a familiar, comforting image at a hospital entrance 2. Provides offices or rooms at the front of building with some privacy from passing vehicular and pedestrian traffic 3. If designed well for sitting and conversing, may provide an appreciated, usable outdoor space	1. Because often not intended for use, its lack of seating, pathways, and so on, may be frustrating for staff or visitors who want to use it, especially if this is the only available outdoor space 2. If the integration of landscaped setback, vehicular and pedestrian approaches is not carefully though through, the result may be a confusing approach to the building.	pg 118-119
3. The Front Porch	some features at the main entrance that are analogous to the front porch of a house. These might include an overhang or porch roof, a turnaround for vehicle pickup and drop-off, seats, directional signs, a postbox, phone, bus stop, and so on.	1. Provides visual cue to main entrance 2. Overhang may scale down size of building 3. Sensitively located seating provides amenity for those waiting to be picked up or waiting for bus	1. May be overused – creating congestion – if it is only outdoor seating area provided 2. May be underused if main access to hospital is via parking under building 3. May be confusing if vehicular and pedestrian needs are not sensitively integrated 4. Often raises conflict of smoking just outside the entry 5. an unpleasant experience for may who are traversing the space.	pg 121
4. Entry Garden	a landscaped area close to a hospital entrance that, unlike a "front porch," is a green space with a garden image, and unlike a "landscaped setback" is designed and detailed for use.	1. The garden is visible and accessible 2. Makes more aesthetic use of part of site that might otherwise have been paved for parking 3. Provides a pleasing image on entering hospital environment 4. Allows use by ambulatory inpatients who want to watch the world go by 5. May successfully double as a public park, and costs of maintenance devolve onto a city department	1. Without sensitive planting, may be too exposed to nearby parking and entry road 2. Depending on the garden's size and location, may impede access to the main entrance 3. Space for garden may have to compete with parking provision 4. High visibility of space may deter inpatients in hospital garb from using it	pg 124
5. Courtyard	walls on all four sides and located at core of building. Ideally, a courtyard should be immediately visible or apparent upon entering the hospital so that visitors and patients know that it is there.	1. Semiprivate and secure; surrounded by hospital building 2. Brings light into the core of the building 3. Depending on location, may be easily viewed and accessed 4. Shielded form wind; building likely to provide shade 5. Likely to be of human scale 6. Can be used to provide way-finding cues from the interior 7. May provide attractive views from windows of offices or patient rooms	1. Depending on its size, location, and design, may create a "fishbowl" experience for those using it 2. If lacking an adequate buffer – planting or structural – adjacent rooms may need to keep blinds drawn for privacy 3. Sounds may intrude into the rooms or from rooms into the courtyard 4. If many courtyards are provided, there may not be the budget or interest in keeping them all well maintained and accessible, as was unfortunately the case in many hospitals observed.	pg 128
6. Plaza	outdoor areas that are predominantly hard-surfaced, but furnished for use. They may include trees, shrubs, or flowers in planters, though the overall image is not of a green space, but of a paved urban plaza	1. Low plant maintenance and irrigation costs 2. A small place can be designed for relatively heavy use 3. Patients using wheelchairs, walkers, or crutches may be able to move easily in this space	1. May have few of the qualities that many people perceive as therapeutic in outdoor space – an overall green and/or colorful setting, a garden or oasis image 2. May evoke the image of a shopping mall or corporate office plaza rather than a space for peaceful, stress reducing, passive enjoyment 3. Reflected heat from hard surfaces may be a deterrent to use 4. Light-colored, paved surfaces may create glare problems, especially for the elderly	pg 132
7. Roof Garden	located on top of building and designed and landscaped for patients, staff, and visitors, and – in some cases – for viewing from offices and hospital units.	1. Captures space that might otherwise be unused 2. Private to people in the hospital; it is unlikely that people "just walking by" would use it 3. Has the potential for expansive views to the surrounding urban or natural landscape	1. Structural problems bay preclude the use of large trees or water features 2. Exposed to elements: may be windier that spaces at ground level of enclosed courtyards 3. Depending on the orientation and height of any adjacent buildings creating shadows, temperatures may be uncomfortably hot or cold 4. Heating/air conditioning units often vent on roofs, creating intrusive mechanical sounds 5. Unless well signed, visitors and patients may not know if its existence	pg 134

TYPES OF OUTDOOR SPACES AT HEALTHCARE FACILITIES				
Outdoor Space:	**Description:**	**Advantages:**	**Disadvantages**	**Reference**
8. Roof Terrace	usually located on the side of a building forming a long narrow "balcony" to that building. It is usually a linear space, predominantly hardscaped but with some garden elements (planters, seating, etc.).	1. Captures space that might otherwise go unused 2. Potential for expansive views	1. Depending on location, may be too exposed – too hot, cold, or windy. 2. Unless carefully designed, use of terrace may intrude on privacy of people in adjacent rooms	pg 135
9. Healing Garden	this is a category that includes indoor and outdoor garden spaces in hospitals that are specifically designated as healing gardens by the administration and the designer	1. Users can expect that some thought has been given to creating an environment that is therapeutic 2. Presence of a healing garden may convey message that the institution has a holistic approach to medical care	1. Some staff members may not embrace the holistic approach to medical care and may question the appropriateness of a healing garden 2. Users may be confused as to appropriate behaviors in the garden	pg 138
10. Meditation Garden	small, very quiet, enclosed space specifically labeled with a plaque as a meditation garden by the administrator or designer.	1. Provides a space for those in a hospital setting who want to be very quiet and contemplative 2. By its name, precludes other, possibly distracting, activities (eating, smoking, etc.)	1. If it is visible from indoor spaces, one might feel self-conscious, in a fishbowl. It is quite probable that only one person at a time might use such a space, depending on its size and its design. 2. Given its designation, one might feel self-conscious about using it for other quiet activities that are not meditation, such as reading or writing.	pg 139
11. Viewing Garden	with space and budget limitations, some hospitals incorporate a small garden that cannot be entered but can be viewed from inside the building.	1. Brings light into the building interior 2. Introduces greenery into a small area 3. Can be viewed from indoor seating, sheltered from rain, and in a heated/air-conditioned space 4. Low maintenance costs compared to accessible and used spaces	1. Greenery, flowers, and so on, cannot be viewed up close, touched, or their fragrances enjoyed 2. A fountain or birds – if present – cannot be heard 3. Hospital users cannot walk, stroll, or sit in garden 4. Inaccessibility of the garden may be frustrating for some – "Look, but don't touch"	pg 142
12. Tucked-away Garden	a space set apart from the building	1. Can make good use of otherwise "leftover" space on the site 2. A short walk to the garden can provide a welcome separation form hospital activities	1. Without good signage, may be sparsely used except by those "in the know"	pg 144
13. Borrowed Landscape	views out onto gardens or natural landscape can provide important stress-reducing experiences for hospital patients, staff, and visitors.	1. A green outlook can be provided with no exposure of land acquisition or maintenance to the hospital 2. Wildlife or people using the space may provide a pleasing diversion, particularly in inclement weather 3. An experience of nature is close at hand, even in inclement weather 4. Views out are complemented by daylight coming in 5. May provide a useful orientation element	1. Unless designated as a park or greenbelt, the space may eventually be built over 2. If ambulatory access to the space is not possible, may be frustrating to some people	pg 148
14. Nature Trails and Nature Preserves	although a rare amenity in a hospital setting, an accessible nature trail or nature/wildlife preserve can provide a welcome outdoor experience, especially for staff on their lunch hour.	1. Can take advantage of the natural landscape surrounding a hospital when it is located in an out-of-town setting 2. A wide variety of species provides interesting views for hospitalized patients 3. Can provide an exercise route that may entice staff outdoors during breaks 4. Can provide an educational and community resource	1. May not be usable by inpatients as a courtyard or entry porch 2. Depending on the local climate, may not be usable all year 3. May raise issues of supervision, especially in secure units	pg 150
15. Atrium Garden	where climate precludes sitting or strolling outdoors through much of the year, an indoor garden – either heated or air-conditioned – can provide an attractive substitute	1. Simulates an "outdoor" green experience during times of inclement weather 2. Provides a space that is undoubtedly part of the hospital's territory and is secure 3. The space is usually very visible and accessible 4. The inside of hospital is flooded with daylight	1. Heating, or cooling, of space increases energy costs 2. Plants may need special care, or entail high maintenance and replacement costs 3. Difficult growing conditions may mandate use of plastic plants	pg 152

APPENDIX B: DESIGN PATTERNS

DESIGN PATTERNS					
Alexander's Pattern	Alexander's Description:	Tyson's Design Objectives			Reference
		Person: Individual's Needs	Place: Physical Environment	Interaction: Behavior	
# 69. Public Outdoor Room	"In every neighborhood and work community, make a piece of the common land into an outdoor room - a partially enclosed place, with some roof, columns, without walls, perhaps with a trellis; place it beside an important path and within view of many homes and workshops" (1977. 351)	1. Provide for safety and security 2. Promote Independence 3. Allow for privacy	1. Integrate indoor and outdoor areas 2. Create comfortable microclimate	1. Create interactive environment 2. Consider a range of abilities	pg 44
# 79. Your Own Home	"Give every household its own home, with space enough for a garden. Indeed, where it is possible to construct forms of ownership which give people control over their house and gardens,...choose these forms above all others. In all cases give people legal power, and the physical opportunity to modify and repair their own places..." (1977, 395)	1. Provide for safety and security 2. Promote Independence 3. Encourage ownership	1. Create comfortable microclimate	1. Create interactive environment 2. Consider a range of abilities 3. Allow for work and recreation	pg 44
# 106. Positive Outdoor Space	"Make all the outdoor spaces which surround and lie between your buildings positive. Give each one some degree of enclosure; surround each space with wings of buildings, trees, hedges, fences, arcades, and trellised walks, until it becomes an entity with a positive quality and does not spill out indefinitely around corners" (1977, 522)	1. Provide for safety and security. 2. Allow for heightened sensory awareness.	1. Create comfortable microclimate 2. Provide interesting walking paths	1. Maximize spatial orientation 2. Encourage social and environmental interaction	pg 45
# 114. Hierarcgy of Open Space	"Whatever space you are shaping - whether it is a garden, terrace, street, park, public outdoor room, or courtyard - make sure of two things. First, make at least one smaller space, which looks onto it and forms a natural back for it. Second, place it, and its openings, so that it looks into at least one larger space. When you have done this, every outdoor space will have a natural 'back,' and every person who takes up the natural position, with his back to this 'back' will be looking out toward some larger distant view" (1977, 559)	1. Provide for safety and security 2. Allow for privacy		1. Maximize spatial orientation 2. Provide a variety of seating choices	pg 45
# 115. Courtyards Which Live	"Place every courtyard in such a way that there is view out of it to some larger open space; place it so at least two or three doors open from the building into it and so that the natural paths which connect these doors open from the building into it and so that the natural paths which connect these foors pass across the courtyard. And, at one edge, beside a foor, make a roofed veranda or a porch, which is continuous with both the inside and the courtyard..." (1977, 564).	1. Encourage personalization	1. Create residential character 2. Provide interesting walking paths	1. Create interactive environment 2. Consider a range of abilities	pg 46
# 119. Arcades	"Wherever pasths run along the edge of buildings, build arcades, and use the arcades, above all, to connect up the buildings to one another so that a person can walk from place to place under the cover of the arcades" (1977, 583)	1. Integrate indoor and outdoor space 2. Provide interesting walking paths		1. Create interactive environment	pg 46
# 120. Paths and Goals	"To lay out the paths, first place goals at natural points of interest. Then conncet the goals to one another to form the paths. The paths may be straight, or gently curving between the goals; their paving should swell around the goal. The goals should never be more than a few hundered feet apart" (1977, 587)	1. Provide for safety and security 2. Promote independence	1. Provide interesting walking paths	1. Create interactive environment 2. Consider a range of abilities 3. Maximize spatial orientation	pg 47
# 121. Path Shape	"Make a bulge in the middle of a punblic path, and make the ends narrower, so that the path forms an enclosure which is a place to stay, not just a place to pass through" (1977, 591)	1. Promote independence 2. Allow for privacy	1. Provide interesting walking paths	1. Create interactive environment 2. Maximize spatial orientation 3. Provide a variety of seating choices	pg 47
# 124. Activity Pockets	"Surround public gathering places with pockets of activity - small, partly enclosed areas at the edges, which jut forward into the open space between the paths, and contain activities which make it natural for people to pause and get involved" (1977, 607)	1. Promote independence	1. Provide interesting walking paths	1. Create interactive enviroment 2. Provide a variety of seating choices	pg 48
# 126. Something Roughly in the Middle	"Between the natural paths which cross a public square or courtyard or a piece of common land, choose something to stand roughly in the middle: a fountain, a tree, a statue, a clock tower with seats, a windmill, a bandstand. Make it something which gives a strong and steady pulse to the square, drawing people in toward the center. Leave it exactly where it falls between the paths; resist the impulse to put it exactly in the middle" (1977, 601)		1. Provide interesting walking paths	1. Create interactive environment 2. Maximize spatial orientation	pg 48
# 127. Intimacy Gradient	"Lay out the spaces of a building so that they create a sequence which begins with the entrance and the most public parts of the building, then leads into the slightly more private areas, and finally to the most private domains" (1977, 613)	1. Allow for privacy		1. Create interactive environment 2. Consider a range of abilities 3. Provide a variety of seating choices	pg 49
# 129. Common Areas at the Heart	"Create a single common area for every social group. Locate it at the center of gravity of all the spaces the group occupies, and in such a way that the paths which go in and out of the building lie tangent to it" (1977, 621)	1. Provide for safety and security 2. Promote independence	1. Create residential character 2. Provide interesting walking paths	1. Create interactive environment 2. Maximize spatial orientation	pg 49
# 142. Sequence of Sitting Spaces	"Put in a sequence of sitting spaces throughout the building, varying according to their degree of enclosure. Enclose the most formal ones entirely, in rooms by themselves; put the least formal ones in covers of the rooms, without any kind of screen around them; and place the intermediate ones with a partial enclosure round them to keep them connected to some larger space, but also partly seperate" (1977, 674)	1. Allow for privacy	1. Create residential character 2. Provide interesting walking paths	1. Create interactive environment 2. Maximize spatial orientation 3. Provide a variety of seating choices	pg 50

DESIGN PATTERNS					
Alexander's Pattern	Alexander's Description:	Tyson's Design Objectives			Reference
		Person: Individual's Needs	Place: Physical Environment	Interaction: Behavior	
# 156. Settled Work	"Give each person, especially as he grows old, the chance to set up a workplace of his own, within or very near his home. Make it a place that can grow slowly, perhaps in the beginning sustaining a weekend hobby and gradually becoming a complete, productive and comfortable workshop" (1977, 735)	1. Promote independence 2. Allow for heightened sensory awareness 3. Encourage personalization	1. Create residential character	1. Create interactive environment 2. Consider a range of abilities 3. Continue familiar tasks	pg 50
# 161. Sunny Place	"Inside a south-facing court, or garden, or yard, find the spot between the building and outdoors which get the best sun. Develop this spot as a special sunny place - make it the important outdoor room, a place to work in the sun, or a place for a swing and some special plants, a place to sunbathe. Be very careful indeed to place the sunny place in a position where it is sheltered from the wind. A steady wind will prevent you from using the most beautiful place" (1977, 759)	1. Promore independence 2. Allow for heightened sensory awareness	1. Create residential character	1. Create interactive environment 2. Consider a range of abilities 3. Continue familiar tasks	pg 51
# 171. Tree Places	"If you are planting trees, plant them according to their nature, to form enclosures, avenues, squares, groves, and single spreading trees toward the middle of open spaces. And shape the nearby buildings in response to trees, so that the tree themselves, and the trees and buildings together, form places which people can use" (1977, 800)	1. Allow for heightened sensory awareness		1. Create interactive environment 2. Maximize spatial orientation	pg 51
# 173. Garden Wall	"Form some kind of enclosure to protect the interior of a quiet garden from the sights and sounds of passing traffic. If it is a large garden or a park, the enclosure can be soft, can include bushes, trees, slopes, and so on. The smaller the garden, however, the harder and more definite the enclosure must become. In a very small garden, form the enclosure with buildings or walls; even hedges and fences will not be enough to keep out sound" (1977, 807)	1. Provide for safety and security 2. Allow for privacy	1. Create comfortable microclimate 2. Create residential character	1. Create interactive environment 2. Provide a variety of seating choices	pg 52
# 176. Garden Seat	"Make a quiet place in the garden - a private enclosure with a comfortable seat, think planting, sun. Pick the place for the seat very carefully; pick the place that will give you the most intense kind of solitude" (1977, 817)	1. Allow for heightened sensory awareness 2. Allow for privacy	1. Create comfortable microclimate 2. Create residential character	1. Create interactive environment 2. Maximize spatial orientation 3. Provide a variety of seating choices	pg 52
# 177. Vegetable Garden	"Set aside one piece of land either in the private garden or on common land as a vegetable garden. About one-tenth of an acre is needed for each family of four. Make sure the vegetable garden is in a sunny place and central to all the households it serves. Fence it in and build a small storage shed for gardening tools beside it" (1977, 820)	1. Promote independence 2. Allow for heightened sensory awareness 3. Encourage personalization	1. Create residential character	1. Create interactive environment 2. Consider a range of abilities 3. Continue familiar tasks	pg 53
# 179. Alcoves	"Make small places at the edge of any common room, usually no more than 6 feet wide and 3 to 6 feet deep and possibly much smaller. These alcoves should be large enough for two people to sit, chat, or play and sometimes large enough to contain a desk or a table" (1977, 832)	1. Promote independence 2. Allow for privacy	1. Create residential character 2. Create interesting paths	1. Consider a range of abilities 2. Maximize spatial orientation 3. Provide a variety of seating choices	pg 53
# 185. Sitting Circles	"Place each sitting space in a position which is protected, not cut by paths or movement, roughly circular, made so that the room itself helps to suggest the circle - not too strongly - with paths and activities around it, so that people naturally gravitate towards the chairs when they get in the mood to sit. Place the chairs and cushions loosely in the circle, and have a few too many" (1977, 859)	1. Allow for privacy 2. Encourage personalization	1. Integrate indoor and outdoor areas 2. Create comfortable microclimate 3. Create residential character	1. Create interactive environment 2. Provide a variety of seating choices	pg 54
# 201. Waist High Shelf	"Build waist-high shelves around at least part of the main rooms where people live and work. Make them long, 9 to 15 inches deep, with shelves or cupboards underneath. Interrupt the shelf for seats, windows and doors" (1977, 922)	1. Promote independence 2. Encourage personalization	1. Create residential character	1. Consider a range of abilities 2. Maximize spatial orientation 3. Continue familiar tasks	pg 54
# 241. Seat Spots	"Choosing good spots for outdoor sears is far more important than building fancy benches. Indeed, if the spot is right, the most simple kind of seat is perfect. In cool climates, choose them to face the sun, and to be protected from the wind; in hot climates, put them in shade and open to summer breezes. In both cases, place them to face activities" (1977, 1120).	1. Promote independence 2. Allow for heightened sensory awareness	1. Create interesting paths	1. Consider a range of abilities 2. Maximize spatial orientation 3. Provide a variety of seating choices	pg 55
# 242. Front Door Bench	"Build a special bench outside the front door where people from inside can sit comfortably for hours on end and watch the world go by. Place the bench to define a half-private domain in front of the house. A low wall, planting, a tree, can help to create the same domain" (1977, 1123)	1. Promote independence 2. Encourage ownership	1. Integrate indoors and outdoors 2. Create comfortable microclimate 3. Create familiar character	1. Consider a range of abilities 2. Maximize spatial orientation 3. Provide a variety of seating choices	pg 55
# 245. Raise Flowers	"Soften the edges of buildings, paths and outdoor areas with flowers. Raise the flower beds so that people can touch the flowers, bend to touch them, and sit by them. And build the flower beds with solid edges, so that people can sit on them, among the flowers too" (1977, 1134)	1. Allow for heightened sensory awareness 2. Ensure personal privacy	1. Create familiar character	1. Create interactive environment	pg 56

APPENDIX C: SUBPATTERNS

SUBPATTERN 1 | Indoors and Outdoors		
Feature	**Description**	**Design Considerations**
1. Window Place	Outdoor spaces should reflect life indoors	1. Indoor seating alcoves with low window sills may look out onto small garden scenes or larger views. 2. Resident rooms should be buffered from direct outdoor activity by an appropriate distance or plantings.
2. Natural Sunlight	Directly adjacent to the secured outdoor area should be places where natural sunlight can enter the indoors as well as provide views outside.	Window treatments should be provided where needed to screen views or glare.
3. Garden Viewing Places	Staff need some strategic vantage points from indoors to be able to observe patients using the outdoor area	
4. Doorways and Entries	Entryways leading to the outdoor area should be easily recognized and accessible to patients.	1. Doors and gateways to secured outdoor areas should be open to patients with full or partial glass panels for maximum visibility to outdoors. 2. Staff may need visual or auditory cues when patients exit to the outdoors
5. Nightime Lighting	Lighting the outdoor areas extends the indoor living and activity areas.	1. Low-level lighting will allow for evening use of outdoor seating areas and pathways. 2. The use of lighting will bring the garden to life at twilight and throughout the evening hours. 3. Pathway lighting can make safe walking passible in the evening hours.

SUBPATTERN 2 | Pathways and Landmarks		
Feature	**Description**	**Design Considerations**
1. The Walking Path	Create a primary walkway that brings people from the main entrance around or through the central outdoor area, connecting important gathering areas and entrances.	It should be wide enough for two or three people to walk and talk side by side.
2. The Strolling Garden Path	A slightly meandering path through a naturally landscaped setting can provide a place for quiet walks and retreat.	Trellises or arbors with vines or climbing flowers, seating alcoves or single benches, can offer opportunities to stop and rest along the way.
3. Just Around the Corner	Every path should have a series of landmarks along the way to invite movement through the garden.	1. Familiar features (birdbaths, bird feeders, benches) can be used as landmarks to encourage movement along the paths through the outdoor space. 2. Pathway landmarks should be placed with natural sight lines at a comfortable walking distance from each other.
4. Familiar Destinations	Important destinations should be easily recognized and identified from all places along the path to facilitate orientation and way finding.	1. Secondary landmarks can be used as way-finding cues and to create interest along the path. 2. When given choices, create known and recognized points to reach smaller goals on the way to destination.

SUBPATTERN 3| Garden Places		
Feature	**Description**	**Design Considerations**
1. Open Spaces	People enjoy open spaces to play, to watch squirrels scampering, or robins hunting for worms. An open area (courtyard, lawn, or terrace) provides an opportunity for distant views and a sense of freedom from the confinement of being indoors.	Create an open area with sky and sunshine and pathways connecting places where people are.
2. Working Garden	Without the events and activities of ordinary life, the garden is not complete.	Provide places for people to continue with familiar tasks in a comfortable setting.
3. Gathering Places	Provide places for group gatherings, harvest celebrations, and picnics.	1. The place should be located near indoor social spaces and activity and at the place where paths naturally cross. 2. There should be at least one common gathering place along the primary pathway that people pass by often. 3. The place should be comfortable for viewing the garden, visiting, and informal friendly greetings.
4. Porches and Terraces	Porches or terraces beside an important pathway or entry can serve as a transition area between the indoors and outdoors. Visitor and drop-off entries (in some situations) as well as entrances to the secured outdoor space can be natural places for informal visiting and viewing.	1. Porches or terraces adjacent to indoor activity areas should accommodate group activities that could naturally move outdoors in appropriate weather. 2. Porches should be partially covered to provide protection from the weather.
5. Sun Room	A conservatory or sun room adjacent to the secured outdoor area can provide a place for viewing, planting and caring for plants, or sitting in the sun. It can be a natural transition to the outdoors.	An aquarium with brightly colored fish can provide a positive, soothing sight for residents to watch.

SUBPATTERN 4 | Enclosure		
Feature	**Description**	**Design Considerations**
1. Gates, Fences, and Screens	The design of gates and fences should be in keeping with the style of the building and surroundings.	Trellised screens can help create comfortable pockets, protected from outside distractions, prevailing winds, and intense heat from the sun. 2. Define the edges of the garden using plantings, screens, or fencing.
2. Awning and Arcades	Awning and arcades can be used to screen direct exposure to harsh weather conditions such as sunlight, rain, snow, or wind and provide a covered place for walking.	1. People need an in-between area to adjust to the outdoor light. 2. An overhead canopy, porch roof, awning, or arbor will filter or shade the glare from bright sunlight.

SUBPATTERN 5 | Garden Views		
Feature	**Description**	**Design Considerations**
1. Distant Views	Views out from the garden or long views within the enclosure of a garden expand the feeling of freedom and connection to the landscape.	
2. Inside Views	Vignettes or small views within the garden help create the illusion of passage through and around the designed landscape. Views connect garden and places.	
3. Filtered Views	Use trees and trellised vines to create a quiet sense of enclosure without completely obstructing the views beyond.	
4. Forced Perspective	Distance between plants or location can accomplish the illusion of either increased or decreased view distances inside or beyond the edge of the garden.	Use plantings and structures to either shorten or lengthen views.
5. Sight-line Views	Strategically located along the paths and from indoors, make visual connections between places and activities to encourage movement into and throughout the garden.	
6. Vignettes	Use plantings or structures to create or frame views in the garden. These captured vignettes help create a succession of experiences.	Plantings with strong silhouettes are best used to frame distant views while softer branching structures can frame selected views inside of the garden from where people tend to sit.

SUBPATTERN 6 | Plantings		
Feature	**Description**	**Design Considerations**
1. Framework Plantings	Specimen trees accompanied by shrub masses or signature plants begin to create the living structure of the garden.	Strategic placement and individual forms of plants are the foundation or framework for the other plantings and green space.
2. Sunny Places, Arbors, and Shade	Provide places for people to sit in the sun, under a canopy or arbor with vines filtering breezes and cooling in summer, or they can be comfortable pockets to extend seasonal use.	For people who are more sensitive to temperature changes, the effects of cold or heat should be minimized.
3. Evolving Gardens	Some gardens within the larger landscape are best when allowed to evolve over time.	People need some place in the garden to create new combinations of plants; to bring plants from home, to grow vegetables and flowers.
4. Flower Borders and Window Boxes	Brightly colored flowers in borders along pathways, in containers or window boxes, add personality and life to the garden.	1. Use vibrant reds, yellows, and oranges to draw people into the garden. 2. Softer hues (blue, pinks, and white) can be used in quiet areas and in shade.
5. Container Gardens	Raising the level of planting is an effective way to bring the garden closer to the observer.	1. Containers of all styles, sizes, and materials can be used in situations where not much green space or open ground is available for planting. 2. Containers can be moved to form enclosure, used as landmarks along pathways and at entrances, and provide small areas for individuals to plant and tend to with a minimum investment of money and time.

SUBPATTERN 7 | Furnishings		
Feature	**Description**	**Design Considerations**
1. Nomadic Chairs	People want to move chairs and tables to suit their needs.	1. Lightweight, sturdy chairs and other furnishings allow people to control their placement to take advantage of the sun, shade, and shelter as desired. 2. Use comfortable and sturdy but lightweight chairs and tables that can be arranged to create a friendly circle for family visits. 3. The surface area should be spacious enough to arrange some chairs in a circle for larger group activities.
2. Council Ring	Create places for people to sit and talk or tell stories.	1. Use permanent seating such as a seat-wall or benches in a circular form that are at a comfortable conversation distance for small groups of 6 to 10 people to gather. 2. The ring can be complemented by movable furniture.
3. Structured Seating	Fixed, strategic placement of some benches and seating areas along the pathways is necessary to assure appropriate locations. The furnishings help form the framework of the garden.	
4. Visiting Alcoves	Along pathways or as part of a larger gathering place, provided small alcoves for three or four people to visit.	1. Use plantings or walls to make it a somewhat private, somewhat public place in the garden. 2. Benches and chairs can be arranged to encourage conversation and visiting.
5. Quiet Places	Single benches along the pathway or in quiet areas of the garden provide a place for people to sit alone or with one other person.	Create these places in areas where people can observe life in the garden.
6. Sculpture and Water Features	The introduction of water can provide places for birds to gather as well as bring an element of soothing sound to the garden.	1. Include sculpture or ornamental water features (e.g., birdbath, small fountain or waterfall, statuary) or a shallow basin for collecting rain. 2. Fountains, reflective pools, and small fish ponds need to be carefully considered if used in these settings due to safety and occasional negative side effects for some people.

APPENDIX D: BIOPHILIC DESIGN ELEMENTS

BIOPHILIC DESIGN ELEMENT 1 | Environmental Features	
The first and most obvious of the biophilic design elements is environmental features, involving the use of relatively well-recognized characteristics of the natural world in the built environment. Twelve attributes are identified, including the following:	
Design Attribute:	**Description:**
1. Color	Color has long been instrumental in human evolution and survival, enhancing the ability to locate food, resources, and water; identify danger; facilitate visual access; foster mobility; and more. People for good and obvious reasons are attracted to bright flowering colors, rainbows, beautiful sunsets, glistening water, blue skies, and other colorful features of the natural world. Natural colors, such as earth tones, are thus often used to good effect by designers.
2. Water	Water is among the most basic human needs and commonly elicits a strong response in people. The effective use of water as a design feature is complex and often contingent on such considerations as perceptions of quality, quantity, movement, clarity, and other characteristics.
3. Air	People prefer natural ventilation over processed and stagnant air. Important conditions include quality, movement, flow, stimulation of other senses such as feel and smell, and visual appeal despite the seeming invisibility of the atmosphere.
4. Sunlight	Daylight is consistently identified as an important and preferred feature by most people in the built environment. The simple use of natural rather than artificial light can improve morale, comfort, and health and productivity. This preference reflects the fact that humans are a largely diurnal animal, heavily reliant on sight for securing resources and avoiding hazard and danger. People depend on visual acuity to satisfy various physical, emotional, and intellectual needs.
5. Plants	Plants are fundamental to human existence as sources of food, fiber, fodder, and other aspects of sustenance and security. The mere insertion of plants into the built environment can enhance comfort, satisfaction, well-being, and performance.
6. Animals	Animals are similarly basic to human existence as sources of food, resources, protection, and companionship, and occasionally as precipitators of fear and danger. Designing animal life into the built environment can be difficult and problematic, although sometimes effective in aviaries, aquaria, and even the presence of free-roaming creatures associated with certain designs like green roofs. Animals in building interiors typically occur in representational rather than literal form, many through the use of ornament, decoration, art, and in stylized and highly metaphorical disguise. The presence of animal forms, nonetheless, often provokes satisfaction, pleasure, stimulation, and emotional interest.
7. Natural Materials	People generally prefer natural over artificial materials, even when the artificial forms are close or seeming exact copies of natural products. Part of the aversion is likely due to the inability of artificial materials to reveal the organic processes of aging, weathering, and other dynamic features of natural materials, even inorganic forms like stone. The patina of time may provoke an intuitive understanding among some people of the benefits flowing from the movement of nutrients and energies through natural systems.
8. Views and Vistas	People express a strong and consistent preference for exterior views, especially when the vistas contain natural features and vegetation. These views are often most satisfying when the scale is compatible with human experience—for example, not overly restricted or confined, unfamiliar, or out of scale or proportion (e.g., too large or too high).
9. Façade Greening	Buildings with vegetative façades, such as ivy walls or green roofs, often provoke interest and satisfaction. This likely reflects the historic benefits associated with organic materials as sources of insulation, camouflaging protection, or even food. Plants on buildings and constructed landscapes can also evoke a powerful vernacular, such as the thatched or vegetative roofs of many cultures.
10. Geology and Landscape	The compatible connection of buildings to prominent geological features is often an effective design strategy. These structures are sometimes described as rooted or grounded. Frank Lloyd Wright achieved particular success with his Prairie-style architecture in part by creating structures that worked in strong parallel relation to rather than dominating their savanna-type landscape.
11. Habitats and Ecosystems	Buildings and landscapes that possess a close and compatible relationship to local habitats and ecosystems also tend to be highly effective and preferred. Important ecosystems in this regard are often wetlands, forests, grasslands, and watersheds.
12. Fire	Fire in the built environment, while a complicated and difficult design challenge, is often a preferred feature, generally associated with the benefits of heating and cooking. The manipulated experience of fire within building interiors has long been celebrated as a sign of comfort and civilization, providing pleasing qualities of color, warmth, and movement.

BIOPHILIC DESIGN ELEMENT 2 | Natural Shapes and Forms	
The second biophilic design element is natural shapes and forms. This element includes representations and simulations of the natural world often found on building façades and within interiors. Eleven attributes are associated with this design element:	
Design Attribute:	**Description:**
1. Botanical Motifs	The shapes, forms, and patterns of plants and other vegetative matter are a frequent and often important design element of the built environment. These representations often mimic or simulate plant forms such as foliage, ferns, cones, shrubs, and bushes, both literally and metaphorically.
2. Trees and Columnar Supports	Trees have also played a vital role in human affairs as sources of food, building material, paper products, heating supply, and other uses. The appearance or simulation of treelike shapes, especially columnar supports, is a common and often coveted design feature in the built environment. Some of our most appealing structures contain tree forms and shapes that frequently include leaf capitals. When revealed in multiples, they can sometimes suggest a forested setting.
3. Animal (mainly vertebrate) motifs	The simulation of animal life is widespread in building interiors and facades, although to a less extent than with plants. The appearance of animal parts is often encountered, such as claws or heads, rather than entire creatures. Animal forms are frequently revealed in highly stylized, fictionalized, and sometime contorted shapes and forms.
4. Shells and Spirals	Simulations and depictions of invertebrate creatures are widespread design features in the built environment, particularly shell and spiral forms of actual and imagined mollusks. The shapes and forms of bees (and their hives), flies, butterflies, moths, and other insects, as well as spiders (and their webs) and other invertebrates, are also common. Some building designs mimic invertebrate processes, such as the bioclimatic controls of termite mounds, the structural strength of seashells and hives, and the patterns of webs, a subject considered at the end of this section under the topic of "biomimicry,"
5. Egg, Oval, and Tubular Forms	Egglike and tubular forms are also design elements in some building interiors, facades, and exterior landscapes such as gardens and fountains. These shapes often occur literally and metaphorically, both important expressions of ornament and sometimes for structural purposes.
6. Arches, Vaults, Domes	Arches, vaults, and domes in the built environment resemble or copy forms found in nature, including beehives, nest-like structures, shell forms, and cliffs. These forms can be used for both decorative and functional purposes.
7. Shapes Resisting Straight Lines and Right Angles	Natural shapes and forms are often sinuous, flowing, and adaptive in responding to forces and pressures found in nature. Natural features are thus rarely revealed as straight lines and right angles characteristic of human engineering and manufactured products and structures. The large-scale modern built environment has often been characterized by standardized and rigid shapes. People nonetheless generally prefer designs that resemble the tendency of organic forms to resist hard mechanical edges, straight lines and angles.
8. Stimulation of Natural Features	This attribute reaffirms the tendency to simulate rather than replicate actual natural forms in the built environment. Ornamentation and decoration especially employ imagined forms only vaguely reminiscent of those found in the natural world. These designs are often most successful when they possess a logic that intimates functional features occurring in nature, such as shapes, patterns and processes that suggest structural integrity and adaptive advantage in response to environmental pressures rather than mere superficial decoration.
9. Biomorphy	Some interesting architectural forms bear very little resemblance to life forms encountered in nature, yet are clearly viewed as organic. These resemblances to living forms are usually unconscious products of design, sometimes called "biomorphy" Powerful examples of biomorphic architecture that provoke observers to impute known animal and plant labels even when the designer did not deliberately create these life-forms include the birdlike shape of Jörn Utzon's Sydney Opera House and the fernlike or less reverently labeled "pregnant whale" of Eero Saarinen's Yale University hockey rink.
10. Geomorphology	Some building designs mimic or metaphorically embrace landscape and geology in relative proximity to the structure. These structures are sometimes described as rooted or grounded. This relationship to the ground can lend the appearance of solidity to the built environment, making structures appear integral rather than separate from their geological context.
11. Biomimicry	Some successful designs borrow from adaptations functionally found in nature, particularly among other species. Examples include the structural strength and bioclimatic properties of shells, crystals, webs, mounds, and hives, effectively incorporated into the built environment. This tendency has been called "biomimicry" by Janine Benyus, elucidated in her book of this title (1997) and connected to biophilic design in a later chapter in this volume. The knowledge of biomimetic properties is growing rapidly and will likely result in a revolution of product development with enormous biophilic design implications.

BIOPHILIC DESIGN ELEMENT 3 | Natural Patterns and Processes	
A third biophilic design element is natural patterns and processes. This element emphasizes the incorporation of properties found in nature into the built environment, rather than the representation or simulation of environmental shapes and forms. Fifteen attributes have been identified and are described below, although this complex element is likely to be altered in the future with additional understanding.	
Design Attribute:	**Description:**
1. Sensory Variability	Human fitness and survival has always required coping with a highly sensuous and variable natural environment, particularly responding to light, sound, touch, smell, and other sensory environmental conditions. Human satisfaction and well-being continue to be reliant on perceiving and responding to sensory variability, especially when this occurs in structured and organized ways within the built environment.
2. Information Richness	Trees have also played a vital role in human affairs as sources of food, building material, paper products, heating supply, and The cognitive richness of the natural world reflects its likely being the most intellectually challenging environment people will ever encounter even in our modern information age.s. This quality constitutes one of its most beguiling features, and when effectively incorporated into the built environment in actual or metaphorical form can stimulate curiosity, imagination, exploration, discovery, and problem-solving. Most people, therefore, respond positively to buildings and landscapes that possess information richness, variety, texture, and detail that mimic natural patterns when coherently revealed.
3. Age, Change and the Patina of Time	A fundamental feature of the natural world is aging through time, particularly organic forms. This dynamic progression evokes a sense of familiarity and satisfaction among people, despite the eventual occurrence of senescence, death, and decay. A patina of time is characteristic of natural materials, even inorganic ones, and is one reason, as noted above, that artificial products rarely evoke sustained positive response even when they are exact copies
4. Growth and Efflorescence	Growth and development are specific expressions of aging that when found in the built environment typically provoke pleasure and satisfaction. Efflorescence marks the progressive unfolding of a maturational process that when encountered in buildings and landscapes, especially through ornamentation, is often highly appealing These temporal and transitional attributes often lend a dynamic quasiliving character to the built environment despite its immutable character.
5. Central Focal Point	The navigability of natural landscapes is often enhanced by the presence of a centrally perceived focal point. This point of reference frequently transforms what otherwise is a chaotic setting into an organized one that facilitates passage and way-finding. Many successful buildings and constructed landscapes similarly achieve coherence despite complexity and large scale when a centrally organized reference point has been effectively incorporated.
6. Patterned Wholes	People respond positively to natural and built environments when variability has been united by integrated and patterned wholes. What may have previously been experienced as inchoate becomes structured in a manner that fosters understanding and often feelings of mastery and control.
7. Bounded Spaces	Humans have a strong proclivity for bounded spaces. This territorial tendency likely fostered resource exploitation and security. People also value delineated spaces within the built environment, which enhance the recognition of clear and consistent boundaries and place demarcations.
8. Transitional Spaces	Transitional spaces within and between built and natural environments often foster comfort by providing access from one area to another. Important passageways in the built environment include thresholds, portals, doors, bridges, and fenestration.
9. Linked Series and Chains	Clear physical and temporal movement in both natural and built environments is often facilitated by linked spaces, especially when occurring in connected chains. These relational spaces convey meaning and organization, as well as sometimes a sense of mystery that both stimulates and entices.
10. Intergration of Parts to Wholes	People prefer in natural built environments the feeling that discrete parts comprise an overall whole, particularly when the whole is an emergent property consisting of more than the sum of the individual parts. This integrative quality fosters a feeling of structural integrity, even in complexes of considerable size and detail.
11. Complementary Contrasts	Meaning and intelligibility, as well as interest and stimulation, in natural and constructed settings often reveal the blending of contrasting features in complementary fashion. This can occur through the compatible rendering of seeming opposites, such as light and dark, high and low, and open and closed.
12. Dynamic Balance and Tension	The dynamic balancing of different and sometimes contrasting forms often fosters a sense of strength and durability in both natural and built environments. This blending of varying forces often produces a quality of creative tension that transforms static forms into organiclike entities.
13. Fractals	Elements in nature are rarely if ever exact copies of one another, even among highly related entities. Snowflakes or leaves of a single species or tree may be highly similar but never the same. Orderly variation on a basic pattern is the norm, whether it be thematic diversity based on size, or spatial or temporal scale. Related and similar forms are often called "fractals," and these patterns are found in some of our most successful buildings and landscapes. These structures frequently include repeated but varying patterns of a basic design, such as ornamentation in parallel or closely linked rows that differ slightly from one another.
14. Hierachically Organized Rations and Scales	Successful natural and built forms often occur in hierarchically connected ways, sometimes arithmetically or geometrically related. This thematic congruence can facilitate the assimilation of highly complex patterns that otherwise might be experienced as overwhelmingly detailed or even chaotic. Arithmetic and geometric expressions of this tendency in both natural and built settings include the golden proportion and the Fibonacci ratio

BIOPHILIC DESIGN ELEMENT 4 | Light and Space	
A fourth biophilic design element is light and space. Twelve design attributes of this element follow, seven focusing on qualities of light and five focusing on spatial relationships:	
Design Attribute:	**Description:**
1. Natural Light	This attribute includes the effects of day-lighting as previously described, as well as inclusion of the full color spectrum of natural light. Natural light is both physically and psychologically rewarding to people, frequently contributing to their health, productivity, and wellbeing in the built environment.
2. Filtered and Diffuesed Light	The benefits of natural light are often enhanced by modulating daylight, particularly by mitigating the effects of glare. Filtered or diffused sunlight can also stimulate observation and feelings of connection by providing a variable and mediated connection between spaces, particularly inside and outside areas
3. Light and Shadow	The complementary contrast of light and dark spaces can produce significant satisfaction in both buildings and landscapes. The creative manipulation of light and shadow can foster curiosity, mystery, and stimulation. This attribute likely evolutionarily enhanced human movement and the ability to discern objects over long distances, particularly from a protected refuge.
4. Reflected Light	Lighting designs are frequently enhanced by light reflecting off surfaces such as light colored walls, ceilings, and reflective bodies like water. Functional benefits include mitigation of glare, enhanced penetration of light into interior spaces, and spying resources at a distance
5. Light Pools	People are often drawn into and through interior spaces by the presence of pools of connected light. Light pools can assist movement and way-finding by providing lighted patches across shadowed or obscured areas such as a forest or darkened halls and passageways. Light pools can also foster feelings of security and protection, such as a lighted hearth.
6. Warm Light	The perception of warmly lit areas, often islands of modulated sunlight surrounded by darker spaces, can enhance the feeling of a nested, secure, and inviting interior.
7. Light as Shape and Form	The manipulation of natural light can create stimulating, dynamic, and sculptural forms. Beyond the aesthetic pleasure, these shapes facilitate mobility, curiosity, imagination, exploration, and discovery.
8. Spaciousness	People prefer feelings of openness in natural and built environments, especially when it occurs in complementary relation to sheltered protected refuges at the surrounding edges. Effective designs often include spacious settings in close alliance with smaller spaces, which in contemporary architecture can often be encountered in airports, train stations, and some commercial and educational buildings.
9. Spatial Variability	Spatial variability fosters emotional and intellectual stimulation. Spatial diversity is often most effective when in complementary relation to organized and united spaces.
10. Space as Shape and Form	Space can be creatively manipulated to convey shapes and forms. This effect can add beauty to the built environment, which stimulates interest, curiosity, exploration, and discovery.
11. Spatial Harmony	The manipulation of space in the built environment tends to be most effective when it blends light, mass, and scale within a bounded context. This achievement evokes a sense of harmony, which fosters a sense of security and facilitates movement within diverse settings.
12. Inside-outside Spaces	Appealing interior spaces in the built environment often appear connected to the outside environment. These areas also mark the transition of nature with culture. Important design forms in the built environment that evoke this quality include colonnades, porches, foyers, atriums, and gardens.

BIOPHILIC DESIGN ELEMENT 5 | Place-Based Relationships	
A fifth biophilic design element is place-based relationships. This element refers to the successful marriage of culture with ecology in a geographical context. The connection of people to places reflects an inherent human need to establish territorial control, which during the long course of our species' evolution facilitated control over resources, attaining safety, and achieving security. Locational familiarity—the yearning for home—remains a deeply held need for most people. Eleven attributes of place-based relationships are described, the last (placelessness) being the antithesis of the others rather than a stand-alone attribute.	
Design Attribute:	**Description:**
1. Geographic Connection to Place	Secure feelings of connection to the geography of an area often foster feelings of familiarity and predictability. This can be achieved by emphasizing prominent geological features associated with the siting, orientation, and views of buildings and landscapes.
2. Historic Connection to Place	Meaningful relation to place often marks the passage of time, which fosters a sense of participation and awareness of an area's culture and collective memory. Buildings and landscapes that elicit this continuity with the past encourage the belief that the present and future are meaningfully linked to the history of a place.
3. Ecological Connection to Place	Places are sustained by an affirmative connection to ecology, particularly prominent ecosystems such as watersheds and dominant biogeographical features (e.g., mountains, deserts, estuaries, rivers, and oceans). The design of the built environment inevitably refashions nature, but this can occur in ways that do not diminish the overall biological productivity (e.g., nutrient flux), biodiversity, and ecological integrity of proximate ecological communities. Humans, like any ecologically transformative organism (e.g., elephants on the savanna, sea otters in a kelp bed), can add as well as subtract value from their natural systems. The design of the built environment can, therefore, aspire to achieve net ecological productivity.
4. Cultural Connection to Place	Cultural connection to place integrates the history, geography, and ecology of an area, becoming an integral component of individual and collective identity. The need for culture is a universal human need, sustained over time by repetition, normative events, and the architectural heritage of a people, particularly its treasured and distinctive vernacular forms.
5. Indigenous Materials	A positive relation to place is generally enhanced by the utilization of local and indigenous materials. Native resources can provide a vivid and resonant reminder of local culture and environment, as well as require less energy for manufacture and transport.
6. Landscape Orientation	Buildings and landscapes that compatibly connect to the local environment contribute to a sense of place. These constructions typically emphasize landscape features such as slope, aspect, sunlight, wind direction, and others that take advantage of prevailing biometeorological conditions. This orientation to landscape frequently evokes a sense of being a part of and embedded within local settings, rather than being separated from them.
7. Landscape Features that Define Building Form	Landscape features can embellish and distinguish building form, particularly prominent geological features, natural objects, and water. The built environment can, therefore, integrate with rather than be isolated from its biophysical context. When this fails to occur, even extraordinary buildings can be perceived as standing apart, perhaps impressive products of human engineering but largely abstract forms divorced from context and barren.
8. Landscape Ecology	Effective place-based designs reinforce landscape ecology over the long term. This can be achieved through design that considers landscape structure, pattern, and process such as ecological connectivity, biological corridors, resource flows, biodiversity, optimal scale and size, ecological boundaries, and other parameters of functioning natural systems
9. Integration of Culture and Ecology	The fusion of culture with ecology fosters long-term sustainability. The result marks the point where nature and humanity are positively transformed and mutually enriched by their association. When this occurs, buildings and landscapes often provoke considerable loyalty, responsibility, and stewardship among the people who reside nearby.
10. Spirit of Place	The spirit of a place signifies a level of commitment and meaning that people extend to both natural and built environments when they become cherished components of individual and collective identity, more than simply inanimate matter. The spirit of a place metaphorically signifies the built environment having become life-life and serving as the motivational basis for long-term stewardship and responsibility. While not technically alive, these structures and places give rise to and sustain human culture and ecology over time.
11. Avoiding Placelessness	"Placelessness" is the antithesis of place-based design, to be avoided whenever possible. One of the insidious and damaging effects of much modern architecture has unfortunately been the divorce of design from connection to the culture or ecology of place. This corrosive separation of the built environment from its biocultural context has resulted in the decline of human-nature relationships and environmental sustainability.

BIOPHILIC DESIGN ELEMENT 6 | Evolved Human-Nature Relationships	
The sixth and final biophilic design element is evolved human-nature relationships. The term is somewhat misleading, as all the described biophilic design elements presumably reflect biologically based human affinities for the natural environment. The attributes described in this section, however, more specifically focus on fundamental aspects of the inherent human relationship to nature. Twelve attributes are described, the last eight of which are derived from a typology of environmental values developed by the author and described elsewhere	
Design Attribute:	**Description:**
1. Prospect and Refuge	Refuge reflects a structure or natural environment's ability to provide a secure and protected setting. In the built environment, this often occurs through the design of comfortable and nurturing building interiors and secreted landscape places. Prospect, on the other hand, emphasizes discerning distant objects, habitats and horizons, evolutionarily instrumental in locating resources, facilitating movement, and identifying sources of danger. Some of our most satisfying buildings and landscapes capture the complementary relation of prospect with refuge
2. Order and Complexity	Order is achieved in the built or natural environment by imposing structure and organization. Extreme order often results in repetition, monotony, and boredom. By contrast, complexity reflects the occurrence of detail and variability. Excessive complexity can also be troublesome, making it difficult to assimilate detail and sometimes leading to a sense of chaos. Designs that effectively meld order with complexity tend to be successful, stimulating the desire for variety but in ways that seem controlled and comprehensible.
3. Curiosity and Enticement	Curiosity reflects the human need for exploration, discovery, mystery, and creativity, all instrumental in problem solving Enticement fosters curiosity. Humans, like any ecologically transformative organism (e.g., elephants on the savanna, sea otters in a kelp bed), can add as well as subtract value from their natural systems. These complementary tendencies can engage the flywheel of human intellect and imagination. Some of our most effective buildings and landscapes foster curiosity, exploration, and discovery of natural process and diversity.
4. Change and Metamorphosis	Change is a constant in both natural and human systems, reflected in the processes of growth, maturation, and metamorphosis Many powerful designs capture this dynamic and developmental quality, where one form or state appears to flow into another in a quasi-evolutionary sequence.
5. Security and Protection	A fundamental objective of the built environment is ensuring protection from threatening forces in nature. Yet, the most successful designs over the long run never accomplish this need at the expense of other equally legitimate environmental values. Security in the built environment must not excessively insulate or isolate people from the natural world.
6. Mastery and Control	Buildings and constructed landscapes reflect the human desire for mastery and control over nature. When accomplished with moderation and respect, mastering nature facilitates the satisfactory expression of human ingenuity and cleverness that fosters self-confidence and self-esteem.
7. Affection and Attachment	Affection for the natural world has been a critical component in engendering the human capacities for bonding and attachment, important in a largely social creature. Buildings and landscapes that elicit strong emotional affinities for nature are typically recipients of lasting loyalty and commitment.
8. Attraction and Beauty	The aesthetic attraction to nature is one of the strongest inclinations of the human species. This biologically encoded tendency has been instrumental in fostering the capacities for curiosity, imagination, creativity, exploration, and problem solving. Some of our most successful buildings and landscapes foster an aesthetic appreciation for natural process and form.
9. Exploration and Discovery	Nature is the most information-rich and intellectually stimulating environment that people ever encounter. Buildings and constructed landscapes that facilitate opportunities for exploration and discovery of natural process elicit considerable interest and appreciation, even when these environmental features are largely revealed in representational ways.
10. Information and Cognition	Intellectual satisfaction and cognitive prowess can be fostered through designs that emphasize the complexity of natural shapes and forms. This can be achieved through the direct and indirect experience of nature, as well as by the creative use of ornamentation in the built environment that fosters critical thinking and problem solving.
11. Fear and Awe	It may seem odd to emphasize negative and unwanted feelings such as fear and aversion of nature as components of biophilic design. Yet, protecting ourselves from threatening elements of the natural world has always been a primary objective of the built environment. Fear of nature can also be a motivational basis for designing peril and adventure into the built environment, such as overhanging precipices or proximity to fearsome forces like rushing water. Feelings of awe for the natural world can further combine reverence with fear, and some of our most celebrated structures achieve this effect through extolling majestic natural features that engender an appreciation for powers greater than ourselves.
12. Reverence and Spirituality	Some of our most cherished buildings similarly affirm the human need for establishing meaningful relation to creation. These designs provoke feelings of transcendence and enduring connection that defy the aloneness of a single person isolated in space and time. Structures that achieve this reverential feeling of connection are also typically sustained generation after generation.

APPENDIX E: APPROVED PLANTS FOR BIOFILTRATION OF INDOOR AIR

Green Plants for Green Buildings

Research has shown the plants on this list help clean indoor air of Volatile Organic Compounds (VOC's) as well as remove CO2. The evidence now with all these species tested, indicates the likelihood that almost any plant species will have a similar VOC and CO2 removal capacity, but research is continuing on this matter. Further, increased worker productivity, decreased absenteeism and improved creativity have been associated with indoor plant usage.

Botanical Name	Common Name
Aechmea primera	Silver Vase Bromeliad
Aglaonema sp.	Chinese Evergreen
Anthurium sp.	
Araucaria heterophylla	Norfolk Island Pine
Asparagus densiflorus	Springerii fern
Asparagus densiflorus 'Meyeri'	Foxtail Fern
Azalea	florist azalea
Brassaia arboricola	Hawaiian Scheff
Calathea sp.	Peacock Plant
Chamaedorea elegans	Parlor Palm
Chamaedorea erumpens	Bamboo Palm
Chamaedorea seifrizii	Reed Palm
Chlorophytum comosum	spider plant
Chrysalidocarpus lutescens	Areca Palm
Chrysanthemum sp.	Pot Mum
Cissus rhombifolia	Grape Ivy
Codiaeum 'Norma'	Croton
Dieffenbachia 'Camille'	Camille Dumbcane
Dieffenbachia 'Starbright'	Starbright Dumbcane
Dieffenbachia 'Tropic Snow Compacta'	Tropic Snow
Dracaena 'Janet Craig'	Janet Craig
Dracaena marginata	Dragon Bush
Dracaena 'Massangeana'	Mass Cane
Dracaena reflexa	Pleomele
Dracaena 'Song of India'	Song of India
Dracaena 'Song of Jamaica'	Song of Jamaica
Dracaena 'Tarzan'	Tarzan
Dracaena 'Warneckii'	Warneckii

Epipremnum aureum	Golden Pothos
Epipremnum aureum 'Jade'	Jade Pothos
Epipremnum 'Marble Queen'	Marble Queen Pothos
Epipremnum 'Neon'	Neon Pothos
Fatsia japonica	Japanese Fatsia
Ficus 'Alii'	Alii Fig
Ficus 'Amstel King'	Amstel Fig Braid
Ficus benjamina	Weeping Fig
Ficus elastica	Rubber plant
Ficus elastica 'Burgundy'	Burgundy
Ficus lyrata	Fiddle Leaf Fig
Ficus 'Monique'	Monique Fig
Ficus 'Spire'	Spire Ficus
Fittonia argyroneura	Nerve Plant
Gerbera jamesonii	Gerbera daizy
Hedera canariensis	Algerian Ivy
Hedera helix	English Ivy
Hemigraphis alternate	Purple Waffle Plant
Howeia fosteriana	Kentia Palm
Hoya carnosa	Wax Plant
Kalanchoe	
Liriope 'Evergreen Giant'	Liriope
Musa sp.	Banana
Neoregelia sp.	Bromeliad
Nephrolepis exaltata	Boston Fern
Nephrolepis 'Kimberly Queen'	Kimberly Queen Fern
Orchid	Varieties will vary
Philodendron 'Hope'	Hope Philodendron
Philodendron 'Imperial Green'	Imperial Green Philodendron
Philodendron 'Imperial Red'	Imperial Red Philodendron
Philodendron oxycardium	Heartleaf Philodendron
Philodendron pertusum	Split Leaf Philo
Philodendron selloum	Lacy-tree Philodendron
Phoenix roebelenii	Date Palm
Poinsettia	
Polyscias crispata 'Chicken Gizzard'	Chicken Gizzard Aralia
Polyscias fruticosa	Ming Aralia

Rhapis excelsa	Lady Palm
Sansevieria laurentii	Variegated Snake Plant
Sansevieria trifasciata	snake plant
Schefflera actinophylla ‘Amate’	Amate
Spathiphyllum clevelandii	Peace Lily
Spathiphyllum 'mauna loa'	Peace Lily
Spathiphyllum 'Petite'	Petite Peace Lily
Spathiphyllum 'Sensation'	Sensation Peace Lily
Spathiphyllum 'Starlight'	Starlight Peace Lily
Spathiphyllum 'Supreme'	Supreme Peace Lily
Syngonium 'White Butterfly'	Nephthytis
Tradescantia pallid	Purple Heart
Zamioculcas zamiifolia	ZZ Plant

Bibliography

"ABC Cancer Center." The Sky Factory, accessed April 28, 2012. www.skyfactory.com/portfolio/#?p=ABC+Cancer+Center&_suid=133601560964008349122801345639

Altman, Irwin. *The Environment and Social Behavior: Privacy, Personal Space, Territory and Crowding.* Monterey, CA: Brooks/Cole, 1976.

Barach, Paul and Kenneth N. Dickerman. "We Shape Our Buildings." World Health Design, accessed April 28, 2012. www.worldhealthdesign.com/We-Shape-Our-Buildngs.aspx.

Barker, Roger G. *Ecological Psychology: Concepts and Methods for Studying the Environment of Human Behavior.* Stanford, CA: Stanford University Press, 1968.

Berlyne, David E. *Conflict, Arousal, and Curiosity.* New York: McGraw-Hill, 1960.

Berlyne, David E. *Aesthetics and Psychobiology.* New York: Appleton-Century-Crofts, 1971.

Berlyne, David E. *Studies in the New Experimental Aesthetics: Steps Toward an Objective Psychology of Aesthetic Appreciation.* New York: Halsted Press, 1974.

Brehm, Jack W. *A Theory of Psychological Resistance.* New York: Academic Press, 1966.

Brunswik, Egon. "Organismic Achievement and Environmental Probability." *Psychological Review,* Vol. 50 (1942): 255-272.

Brunswik, Egon. *Perception and the Representative Design of Psychological Experiments.* Berkeley: University of California Press, 1956.

Burnett, James. "Healing Gardens?" *Healthcare Design Magazine*, May, 2003: 21-23.

Cama, Rosalyn. *Evidence-based Healthcare Design.* Hoboken, New Jersey: John Wiley & Sons, 2009.

Chambers, Nancy. "A New Model for Horticultural Therapy Documentation in a Clinical Setting." *Journal of Therapeutic Horticulture, (*2009): 55-63.

Chaudhury, Habib, Atiya Mahmood, and Maria Valente. "The Effect of Environmental Design on Reducing Nursing Errors and Increasing Efficiency in Acute Care Settings: A Review and Analysis of the Literature." *Environment and Behavior.* Vol. 41, no. 6 (November, 2009): 755-786.

Chein, Isidor. "The Environment as a Determinant of Behavior." *Journal of Social Psychology*, Vol. 29 (1954): 115-127.

Corazon, Sus Sola, Ulrika K. Stigsdotter, Anne Grete Claudi Jensen, and Kjell Nilsson. "Development of the Nature-Based Therapy Concept for Patients with Stress-Related Illness at the Danish Healing Forest Garden Nacadia." *Journal of Therapeutic Horticulture,* (2010): 33-51.

Devlin, Ann Sloan and Allison B. Arneill. "Health Care Environments and Patient Outcomes: A Review of the Literature." *Environment and Behavior* Vol. 35, no. 5 (September, 2003): 665-694.

Fjeld, Tove and Charite Bonnevie. "The Effect of Plants and Artificial Day-light and Health of Office Workers, School Children and Health Care Personnel." Paper presented at the Floriade 2002 World Horticulture Expo Plants for People Conference, The Netherlands, 2002.

Gerlach-Spriggs, Nancy, Richard Enoch Kaufman, and Sam Bass Warner, Jr. *Restorative Gardens: The Healing Landscape.* New Haven, CT: Yale University Press, 1998.

Gibson, James J. "The Theory of Affordances and the Design of the Environment." Paper presented at the annual meetings of the American Society for Aesthetics, Toronto. 1976.

Gibson, James J. *An Ecological Approach to Visual Perception.* Boston: Houghton Mifflin, 1979.

Gilford, Robert. *Environmental Psychology: Principles and Practice,* Third Edition. Canada: Optima Books, 2002.

Haller, Rebecca L. and Christine L Kramer. *Horticulture Therapy Methods: Making Connections in Health Care, Human Service, and Community Programs.* CRC Press, 2006.

Hamilton, D. Kirk. "The Four Levels of Evidence-Based Practice." *Healthcare Design Magazine,* November 1, 2003, 18-26. http://www.healthcaredesignmagazine.com/article/four-levels-evidence-based-practice.

Hartig, T., Mang, M. and Evans, G. W. "Restorative Effects of Natural Environment Experiences." *Environment and Behavior*, Vol. 23 (1991): 3–26.

Herzog, T. R., Black, A. M., Fountaine, K. A. and Knotts, D. J. "Reflection and Attentional Recovery as Distinctive Benefits of Restorative Environments." *Journal of Environmental Psychology,* Vol. 17 (1997): 165–170.

Kaplan, Rachel. "The Psychological Benefits of Nearby Nature." *The Role of Horticulture in Human Well-Being and Social Development: A National Symposium,* Arlington Virginia, April 19-21, 1990. Portland, Oregon: Timberland Press, 1992. 125-133

Kaplan, Rachel and Kaplan, Stephen. *The Experience of Nature: A Psychological Perspective.* Cambridge, New York: Cambridge University Press, 1989.

Kaplan, Stephen. "The Restorative Environment: Nature and Human Experience." *The Role of Horticulture in Human Well-Being and Social Development: A National Symposium,* Arlington Virginia, April 19-21, 1990. Portland, Oregon: Timberland Press, 1992. 134-142.

Kaplan, Stephen and Rachel Kaplan. *Cognition and Environment: Functioning in an Uncertain World.* New York: Praeger, 1982.

Kellert, Stephen R. *Building for Life: Designing and Understanding the Human-Nature Connection.* Washington DC: Island Press, 2005.

Kellert, Stephen R., Judith Heerwagen, and Martin Mador. *Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life.* Hoboken, New Jersey: John Wiley and Sons, Inc., 2008.

Kline, Grace A. "Does A View of Nature Promote Relief From Acute Pain?" *Journal of Holistic Nursing,* American Holistic Nursing Association, Vol. 27, no. 3 (September, 2009): 159-166.

Kopec, Dak. *Environmental Psychology for Design.* New York, NY: Fairchild Publications, Inc.,2006.

Larson, Jean. "Healing by Design: Healing Gardens and Therapeutic Landscapes." *Implication.* Vol. 2, Issue 10 (November, 2004).

LEED 2009 for Healthcare. Washington, DC: U.S. Green Building Council, Inc., 2010.

Levin, Debra J. "The Growing Conversation Around Evidence-Based Design." *Healthcare Design Magazine,* April 1, 2011, 8-9. http://www.healthcaredesignmagazine.com/article/growing-conversation-around-evidence-based-design.

Lewis, Charles A. *Green Nature Human Nature: The Meaning of Plants in Our Lives.* University of Illinois Press, February 1, 1996.

Lobell, John. *Between Silence and Light: Spirit in the Architecture of Louis I. Kahn.* Boston, MA: Shambhala, 1979.

Lohr, V.I. and C.H. Pearson-Mims. "Particulate Matter Accumulation on Horizontal Surfaces in Interiors: Influence of Foliage Plants." *Atmospheric Environment,* Vol. 30, no. 14 (1996): 2565-2568.

Lynch, Kevin. *The Image of the City.* Cambridge, MA: MIT Press, 1960.

Malkin, Jain. "A Tour of the Healing Environment." *Healthcare Design Magazine,* November 1, 2001. http://www.healthcaredesignmagazine.com/article/tour-healing-environment.

Malkin, Jain. *A Visual Reference to Evidence-Based Design.* The Center for Health Design, March 1, 2008.

Marcus, Clare Cooper. "Healing Gardens in Hospitals." *IDRP Interdisciplinary Design and Research e-Journal,* Vol.1, Issue 1: Design and Health (January 2007). http://www.idrp.wsu.edu/.

Marcus, Clare Cooper and Marni Barnes. *Healing Gardens: Therapeutic Benefits and Design Recommendations.* New York, NY.: John Wiley & Sons, 1999.

Marcus, Clare Cooper and Marni Barnes. *Gardens in Healthcare Facilities: Uses, Therapeutic Benefits, and Design Recommendations.* Martinez, CA.: Center for Health Design, 1995.

Martin, Caren S. "The Challenge of Integrating Evidence-Based Design." *Health Environments Research and Design Journal,* (Spring 2009): 29-50.

Mayer, F. Stephan, Cynthia McPherson Frantz, Emma Bruehlman-Senecal, and Kyffin Dolliver. "Why is Nature Beneficial?: The Role of Connectedness to Nature." *Environment and Behavior,* (Vol. 41, no. 5 (September 2009): 607-643.

McCullough, Cynthia. *Evidence-based Design for Healthcare Facilities*. Indianapolis, IN: Sigma Theta Tau International, 2010.

Mehrabian, Albert and James A. Russell. *An Approach to Environmental Psychology.* Cambridge, MA: MIT Press, 1974.

Mitchell, Shannon. "Better Than a Pain Pill." *Healthcare Design Magazine,* August 26, 2011. http://www.healthcaredesignmagazine.com/article/better-pain-pill.

Nisbet, Elizabeth K., John M. Zelenski and Steven A. Murphy. "The Nature Relatedness Scale: Linking Individuals' Connection With Nature to Environmental Concern and Behavior." *Environment and Behavior,* Vol. 41, no. 5 (September, 2009): 715-740.

Park, Seong-Hyun. "Randomized Clinical Trials Evaluating Therapeutic Influences of Ornamental Indoor Plants in Hospital Rooms on Health Outcomes of Patients Recovering From Surgery." PhD diss., Kansas State University, 2006.

Pati, Debajyoti. "A Framework for Evaluating Evidence in Evidence-Based Design." *Health Environments Research and Design Journal,* (Spring 2011): 50-71.

Raza, S. H., G. Shylaja, M.S.R. Murthy, and O. Bhagyalakshmi. "The Contribution of Plants for CO2 Removal from Indoor Air." *Environmental International,* Vol. 17 (1991): 343-347.

Relf, Diane ed. *The Role of Horticulture in Human Well-Being and Social Development: A National Symposium,* Arlington Virginia, April 19-21, 1990. Portland, Oregon: Timberland Press, 1992.

Rotter, Julian B., June E. Chance, and E. Jerry Phares. *Applications of a Social Learning Theory of Personality.* New York: Holt, Rinehart & Winston, 1972.

Rotter, Julian B. *The Development and Application of Social Learning Theory.* New York: Praeger, 1982.

Russell, James A., Lawrence M. Ward, and Geraldine Pratt. "Affective Quality Attributed to Environments: A Factor Analytical Study." *Environment and Behavior,* Vol. 12, no. 2 (1981): 259-288.

Said, Ismail and Mohd Sarofil Abu Bakar. "Affordances of Ward and Garden in the Restorative Process of Hospitalized Children." *Journal of Therapeutic Horticulture,* (2007-2008): 19-31.

Sehulster, Lynne and Raymond Y.M. Chinn. "Guidelines for Environmental Infection Control in Health Care Facilities. *MMWR*, Vol. 52, no. RR-10 (June 6, 2003): 1-42. http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5210a1.htm.

Seligman, Martin. E. P., *Helplessness,* Second Edition. New York: W.H. Freeman and Company, 1992.

Shoemaker, Candice A. and Elizabeth R. Messer Diehl. *Interaction by Design: Bringing People and Plants Together for Health and Well-Being, First Edition.* Proceedings of an International Symposium, Chicago Botanical Garden, July 20-22, 2000. Iowa State Press, 2002.

Shareef, Reginald. "Cleaning the Air: Horticulture as a Quality-of-Life Intervention." *The Role of Horticulture in Human Well-Being and Social Development: A National Symposium,* Arlington Virginia, April 19-21, 1990. Portland, Oregon: Timberland Press, 1992. 110-112.

Simson, Sharon P and Martha C. Straus. *Horticulture as Therapy: Principles and Practice.* Haworth Press, 1998.

Smith, Jerry. "Connection to the Natural World: Places of Respite Technical Brief." *Green Guide for Health Care,* Version 2.2*,* June 29, 2007.

Smith, Jerry. "Design with Nature." *Healthcare Design Magazine,* February 1, 2007. http://www.healthcaredesignmagazine.com/article/design-nature.

Smith, Jerry. "Health and Nature: The Influence of Nature on Design of the Environment of Care." The Center for Healthcare Design, October, 2007.

Sternberg, Esther M. *Healing Spaces: the Science of Place and Well-Being.* Cambridge, Mass: Belknap Press of Harvard University Press, 2009.

Taft, Sheila B. "The Use of Therapeutic Horticulture in Cancer Support." *Journal of Therapeutic Horticulture,* (2007-2008): 45-57.

Tyson, Martha M. *The Healing Landscape: Therapeutic Outdoor Environments.* New York, New York: McGraw-Hill, 1998.

Ulrich, Roger S. "Effects of Healthcare Environmental Design on Medical Outcomes." Proceedings of the Second International Conference on Design and Health, Stockholm, Sweden, 2001: 49-59.

Ulrich, Roger S. "Effects of Interior Design on Wellness: Theory and Recent Scientific Research." *Journal of Health Care Interior Design,* Vol. 3 (1992): 97-109.

Ulrich, Roger S. "Health Benefits of Gardens in Hospitals." Paper presented at the Floriade 2002 World Horticulture Expo Plants for People Conference, The Netherlands, 2002.

Ulrich, Roger S. "View Through a Window May Influence Recovery From Surgery." *Science* Vol. 224, no. 4647 (April 27, 1984): 420-421.

Ulrich, Roger S. and Craig Zimring. "The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity." Report to The Center for Health Design for the "Designing the 21st Century Hospital Project." September 2004.

Ulrich, Roger S. and Russ Parson. " Influences of Passive Experiences with Plants on Individual Well-Being and Health. *The Role of Horticulture in Human Well-Being and Social Development: A National Symposium,* Arlington Virginia, April 19-21, 1990. Portland, Oregon: Timberland Press, 1992. 93-105.

Verges, Michelle and Sean Duffy. "Connected to Birds but Not Bees: Valence Moderates Implicit Associations With Nature." *Environment and Behavior,* (June 10, 2009): 625-642.

Vincent, Ellen Anita. "Therapeutic Benefits of Nature Images on Health." PhD diss., Clemson University, August 2009.

Wagenaar, Cor, ed., Agnes E. van den Berg, Terry Hartig, Wytze Patijin, and Roger S. Ulrich. "Evidence Based Design: Architecture as Medicine?" *Proceedings of an International Symposium for the Architecture of Hospitals*, The Netherlands: University Medical Center Groningen, November 22, 2003.

Wapner, Seymour. "Transactions of Persons-in-Environments: Some Critical Transactions." *Journal of Environmental Psychology,* Vol. 18 (1981): 102-112.

Watkins, Nicholas. "Lost in Translation: Bridging Gaps Between Design and Evidence-Based Design." *Health Environments Research and Design Journal,* (Winter 2008).

Weisz, John R., Fred M. Rothbaum, and Thomas C. Blackburn. "Standing in and Standing Out: The Psychology of Control in America and Japan." *American Psychologist,* Vol. 39 (1984): 955-969.

Wilson, Edward O. *Biophilia.* Cambridge, Mass: Harvard University Press, 1984.

Wilson, Edward O. *Consilience: The Unity of Knowledge.* New York, NY: Vintage Books, 1999.

Wohlwill, Joachim F. "The Physical Environment: A problem for a Psychology of Stimulation." *Journal of Social Issues,* Vol. 22, no. 4 (1966): 28-29.

Wood, R.A., M.D. Burchett, R.A. Orwell, J. Tarran, and F.Torpy. "Potted-planted/growth Media Interactions and Capacities for Removal of Volatiles from Indoor Air." In *Proceedings of Healthy Buildings 2003, 7th International Healthy Buildings Conference*. National University of Singapore, 2003.

Wood, Ronald A. and Margaret D. Burchett. "Monitoring Indoor Plant Responses to Air Pollution – A Tool for Improving Air Quality." In *The Healing Dimensions of People-Plant Relations: Proceedings of a Research Symposium.* University of California at Davis, March 24-27, 1994.

Wood, Ronald. A. "Using Pot Plants to Clean Indoor Air." *Nursery Paper* Issue no. 9 (October 2004).

Zimring, Craig and Sheila Bosch. "Building the Evidence Base for Evidence-Based Design: Editors' Introduction." *Environment and Behavior* Vol. 40, no. 2 (March, 2008): 147-150.

Chapter 5 Precedent Images:

Ashen + Allen (Figures 7, 8): www.anshen.com/index2.htm

Broadway Malyan and Ong & Ong (Figures 46, 47): www.broadwaymalyan.com; www.ong-ong.com/index.php

HDR Inc. (Figures 14, 20, 21, 22, 27, 41, 42, 54): www.hdrinc.com

Karlsberger (Figures 3, 4, 33, 34, 35, 53): www.karlsberger.com

KMD Architects (Figures 48, 49): www.kmdarchitects.com

Mahan Rykiel Associates (Figures 23, 25): www.mahanrykiel.com

NBBJ (Figures 13, 26): www.nbbj.com

Perkins + Will (Figures 9, 18): www.perkinswill.com

RTKL Associates, Inc. (Figures 5, 6, 10, 11, 12, 19, 24, 28, 29, 30, 31, 32, 36, 37, 38, 39, 40, 43, 44, 45, 51, 56, 57, 58, 59): www.rtkl.com

Skidmore, Owings, & Merrill (SOM) (Figure 52): www.som.com

The Office of James Burnett (Figure 15): www.ojb.com

Vapiano Restaurant (Figures 16, 17): www.vapianointernational.com/vapiano

WHR Architects (Figure 55): www.whrarchitects.com

ZGF Architects (Figure 50): www.zgf.com